Thesis/
Reports
Wesche,
T. A.

AQUATIC BIOTA AND ABIOTA OF THE LITTLE POWDER RIVER IN THUNDER BASIN NATIONAL GRASSLAND, WYOMING

Thomas A. Wesche

1630

AQUATIC BIOTA AND ABIOTA OF THE LITTLE POWDER RIVER IN THUNDER BASIN NATIONAL GRASSLAND, WYOMING

February, 1975

Thomas A. Wesche
Robert D. Kerr
Duaina Baldridge

A

Report

by

WATER RESOURCES RESEARCH INSTITUTE

University of Wyoming
Laramie, Wyoming

AQUATIC BIOTA AND ABIOTA OF THE LITTLE POWDER RIVER IN THUNDER BASIN NATIONAL GRASSLAND, WYOMING

February, 1975

Thomas A. Wesche Robert D. Kerr
Duaina Baldridge

Water Resources Research Institute
University of Wyoming

Completion Report
Presented to

U.S. Department of Agriculture
Rocky Mountain Forest and Range Experiment Station
Under the SEAM Program

On

Cooperative Agreement 16-416-CA

LIBRARY

MAY 15 1975

ROCKY MOUNTAIN STATION

ABSTRACT

In light of proposed resource development and as little such study has been undertaken in previous years, the objective of this investigation has been to generate baseline data defining the aquatic biota and abiota of the Little Powder River through the Thunder Basin National Grassland of northeast Wyoming.

Three study sites were selected in May, 1974. Water quality and benthic fauna sampling were conducted on June 12-13, August 20 and October 31-November 1 of 1974, while fish populations were sampled on June 12-13. Other physical data were also gathered to better describe the Little Powder River habitats.

The Little Powder River is a turbid, meandering, low-gradient perennial stream. Fish populations in this cool-warmwater habitat were found to be quite dense, the most abundant species being sand shiners, black bullheads, green sunfish, white suckers and fathead minnows. Benthic fauna was not abundant, averaging only 44.7 organisms per 0.1 m^2. The most common forms were oligocheates, Diptera larvae, mayfly nymphs (g. Caenis) and freshwater clams and snails. The water quality parameter which appeared to influence the aquatic biota to the greatest extent was turbidity. By reducing light penetration and thereby the growth of aquatic vegetation, turbidity may limit the cover and food available to the benthic fauna. Other water quality data collected indicate that leaching from the natural mineral deposits has resulted in high concentrations of sodium, sulfates and chlorides, which was reflected in the specific conductance readings and total dissolved solids concentrations. Other parameters were generally within expected limits.

ACKNOWLEDGMENTS

Research on which this report is based was funded by a grant to the Water Resources Research Institute, University of Wyoming, from the Rocky Mountain Forest and Range Experiment Station, U. S. Department of Agriculture, under the SEAM Program.

Recognition is also made of the help and cooperation of the following persons:

Dr. John Thilenius, Coordinator, SEAM Program, Rocky Mountain Forest and Range Experiment Station, Laramie;

Mr. and Mrs. Frank Ray and Mr. and Mrs. Ed Norfolk, landowners, Weston, Wyoming;

Mr. John Mueller and Mr. L. C. "Red" Rockett, Wyoming Game and Fish Department, Buffalo, Wyoming;

Mr. Bob Freytag, Wyoming Department of Agriculture Chemical and Bacteriological Laboratory, Laramie;

Mr. Paul A. Rechard, Dr. Fred Lawson, Mr. Alan Sullivan, Mr. Lawrence Kimble, Mrs. Pam Murdock and Mrs. Linda Parker, University of Wyoming, Laramie.

TABLE OF CONTENTS

CHAPTER		Page
I.	INTRODUCTION	I- 1
II.	METHODS AND MATERIALS	II- 1
	Physical	II- 1
	Biological	II- 3
	Fisheries	II- 3
	Benthic Invertebrates	II- 5
	Water Quality	II- 8
III.	DESCRIPTION OF STUDY AREA	III- 1
	The Basin	III- 1
	The Study Area	III- 4
	Site No. 1	III- 4
	Site No. 2	III- 9
	Site No. 3	III-12
IV.	RESULTS	IV- 1
	Biological	IV- 1
	Fisheries	IV- 1
	1974 Collections	IV- 1
	Biology of Species Collected	IV-10
	Benthic Invertebrates	IV-23
	Site No. 1	IV-23
	Site No. 2	IV-31
	Site No. 3	IV-32
	Water Quality	IV-37

TABLE OF CONTENTS
(CONTINUED)

CHAPTER		Page
V.	DISCUSSION	V- 1
VI.	SUMMARY AND RECOMMENDATIONS	VI- 1
VII.	LITERATURE CITED	VII- 1

LIST OF TABLES

TABLE		Page
II - 1.	BOTTOM SAMPLING TECHNIQUES USED AT THE LITTLE POWDER RIVER STUDY SITES	II- 6
II - 2.	SAMPLING AND TESTING TECHNIQUES USED FOR LITTLE POWDER RIVER WATER QUALITY SAMPLES	II-10
III- 1.	TRANSECT HYDRAULIC DATA AT THE THREE LITTLE POWDER RIVER STUDY SITES AT 2.4 CFS	III- 7
III- 2.	SURFACE AREA COMPOSITION (FT^2) BY WATER DEPTH CLASS FOR THE THREE LITTLE POWDER RIVER STUDY SITES AT 2.4 CFS	III- 8
IV - 1.	TAXONOMIC CLASSIFICATION OF FISHES COLLECTED FROM THE LITTLE POWDER RIVER	IV- 2
IV - 2.	FISH SPECIES OF THE LITTLE POWDER RIVER AS REPORTED BY BAXTER-SIMON, 1970	IV- 3
IV - 3.	LENGTH-WEIGHT DATA FOR FISH SPECIES COLLECTED FROM THE LITTLE POWDER RIVER ON JUNE 12 AND 13, 1974 . .	IV- 5
IV - 4.	SPECIES COMPOSITION OF FISH POPULATIONS AT THE LITTLE POWDER RIVER STUDY SITES EXPRESSED AS PERCENT OF TOTAL NUMBERS AND WEIGHT	IV- 6
IV - 5.	STANDING CROP ESTIMATES FOR FISH SPECIES COLLECTED AT THE THREE LITTLE POWDER RIVER SAMPLING SITES ON JUNE 12 AND 13, 1974	IV- 7
IV - 6.	SHANNON SPECIES DIVERSITY INDEX VALUES ($\bar{H}$) FOR THE FISH POPULATIONS SAMPLED AT THE THREE LITTLE POWDER RIVER STUDY SITES ON JUNE 12 AND 13, 1974	IV- 9

LIST OF TABLES
(CONTINUED)

TABLE		Page
IV - 7.	TAXONOMIC CLASSIFICATION OF BENTHIC FAUNA FROM THE LITTLE POWDER RIVER	IV-24
IV - 8.	SUMMARY OF BOTTOM FAUNA COLLECTED AT LITTLE POWDER RIVER SITE NO. 1	IV-25
IV - 9.	SUMMARY OF BOTTOM FAUNA COLLECTED AT LITTLE POWDER RIVER SITE NO. 2	IV-26
IV- 10.	SUMMARY OF BOTTOM FAUNA COLLECTED AT LITTLE POWDER RIVER SITE NO. 3	IV-27
IV- 11.	RELATIVE ABUNDANCE OF BOTTOM FAUNA ON A NUMBERS BASIS AT THE THREE LITTLE POWDER RIVER STUDY SITES .	IV-28
IV- 12.	RELATIVE ABUNDANCE OF BOTTOM FAUNA ON A BIOMASS BASIS AT THE THREE LITTLE POWDER RIVER STUDY SITES .	IV-29
IV- 13.	SHANNON SPECIES DIVERSITY INDEX VALUES FOR BOTTOM FAUNA COLLECTED AT THE THREE LITTLE POWDER RIVER STUDY SITES	IV-33
IV- 14.	RESULTS OF KRUSKAL-WALLIS RANK-SUM TESTS FOR SHANNON SPECIES DIVERSITY INDEX VALUES	IV-34
IV- 15.	SUMMARY OF RELATIVE ABUNDANCE DATA FOR THE BOTTOM FAUNA OF THE LITTLE POWDER RIVER	IV-35
IV- 16.	LITTLE POWDER RIVER WATER QUALITY DATA	IV-38
IV- 17.	MAXIMUM, MINIMUM, AND EXPECTED AVERAGE VALUES FOR WATER QUALITY PARAMETERS AS LISTED IN TABLE IV-16 .	IV-40

LIST OF FIGURES

Figure		Page
III-1.	Location Map of Little Powder River Study Sites in Wyoming	III- 2
III-2.	Drainage Basin Map of the Little Powder River	III- 5
III-3.	Surface Area Map of Study Site No. 1	III- 6
III-4.	Photos of Little Powder River Study Site No. 1	III-10
III-5.	Surface Area Map of Study Site No. 2	III-11
III-6.	Photos of Little Powder River Site No. 1	III-13
III-7.	Surface Area Map of Study Site No. 3	III-14
III-8.	Photos of Little Powder River Site No. 3	III-16
IV- 1.	Length-Frequency Distribution of Green Sunfish Collected from the Little Powder River	IV-11
IV- 2.	Length-Frequency Distribution of Black Bullheads Collected from the Little Powder River	IV-12
IV- 3.	Relative Abundance of Bottom Fauna at the Three Little Powder River Study Sites	IV-30

CHAPTER I

INTRODUCTION

Increasing state, regional, and national interest is presently being shown in the development of the sub-bituminous coal deposits underlying the Powder River Basin of Wyoming. A portion of these deposits lie on or in the near vicinity of Thunder Basin National Grassland, administered by the U. S. Forest Service. At present, land use in this area is based primarily upon agriculture. However, it is anticipated that such use will probably be changing in the future as development of mineral resources proceeds. As this occurs, both the terrestrial and aquatic environments of the area will be affected, either directly or indirectly.

In past years, little definitive study has been directed toward the aquatic communities existing in the ephemeral, intermittent and perennial stream channels which drain Thunder Basin lands. Without such data, the ability of Forest Service personnel to determine and implement suitable management policies for these lands is reduced. Thus, the objective of this study has been to begin to develop such necessary baseline information by inventorying and evaluating the native benthic fauna, fish populations and water quality of the Little Powder River as it flows through the Thunder Basin National Grassland in Campbell County, Wyoming.

CHAPTER II

METHODS AND MATERIALS

Physical

The three reaches of the Little Powder River investigated during this study were selected on May 16, 1974 by personnel of the U. S. Forest Service and the principal investigators. Criteria applied for site selection were:

1) location within the boundaries of Thunder Basin National Grassland;
2) representation of other reaches of the Little Powder River in the Grassland;
3) accessability.

On June 12 and 13, 1974, baselines were surveyed along one streambank of each study site, with marker stakes being placed at five-foot invervals (example on Figure III-3, page III-6). These baselines were then used to map the surface area of the stream and also for sample location purposes. Mapping was conducted by measuring the distance from each stake, perpendicular to the baseline, to the stream edge. Survey techniques were also employed to determine the channel slope and bank slopes at each study area.

Cross-channel transects were selected at each site during the June sampling period to measure water depths (taken at one-foot intervals across the stream), top widths and cross-sectional areas. Seven such transects were selected at Site No. 1, while six were used at Sites 2 and 3. Each transect was selected as being hydraulically representative of a given portion of the study reach. The total surface area of each

site could then be broken down into a four-class water-depth system, comprised of the following depth intervals: <0.50 feet; 0.50-0.99 feet; 1.0-1.49 feet; and, $\geq$ 1.50 feet. By computing the percentage of a given transect in each depth class and multiplying this value by the surface area represented by that transect, the depth composition of that portion of a study reach was determined. Summing all transect-surface area values in each of the four depth classes, resulted in the total water-depth composition of a study area (for example, see Table III-2, page III-8). Along one transect at each site, a discharge measurement was made following standard U.S.G.S. procedure, as described by Corbett, 1962. Velocity measurements were taken at one-foot intervals across the channel at the 0.6 depth using a Price current meter.

Drainage basin characteristics of the Little Powder River watershed above the three sampling locations were measured from 1:250,000 U. S. Army Map Service topography maps. The drainage area in square miles was determined by planimetric techniques using a Keuffel and Esser Compensating Polar Planimeter, while total stream length, including all perennial, intermittent and ephemeral channels, was measured with a Keuffel and Esser Map Measurer. Drainage density for the basin was then computed by dividing the total stream length (in miles) by the drainage area (in square miles). The Strahler method was used to determine stream order (Chorley, 1969). In this method, unbranched streams are numbered 1, streams with two or more tributaries rated as 1 are numbered 2, streams with two or more tributaries rated as 2 are numbered 3 and so on.

U.S.G.S. streamflow records for the Little Powder River were obtained from, 1973 Water Resources Data for Wyoming: Part 1. Surface Water Records.

Biological

Fisheries

The fish populations present at the three Little Powder River study sites were sampled on June 12 and 13, 1974. All collections were made using 25 and 50 foot nylon seines having a depth of four feet and a 0.1875 inch mesh size. Electrofishing techniques could not be employed. The turbid water conditions encountered would have hampered the recovery of stunned fish due to poor visibility. For each fish collected, total length was measured to the nearest 1.0 millimeter and weight was recorded to the nearest 1.0 gram. To avoid misidentification of juvenile forms, primarily of minnow species (Family Cyprinidae), representative individuals were preserved in 95 percent alcohol and transported to Laramie for verification using the keys developed by Baxter and Simon, 1970.

Fish population estimates were made at each site using the DeLury Removal Method (DeLury, 1947 and 1951). This procedure involved the following steps:

1. The study area was blocked off using natural barriers and seines to prevent escapement from or recruitment to the population.
2. Three seine hauls, each covering the entire enclosed area, were made, with the fish from each haul being placed in a separate "live car" (holding pen).
3. Treating each haul separately, all fish were identified, enumerated, measured and weighed.
4. A graph was then constructed using the Y-axis as the catch for each seine haul and the X-axis as the cumulative catch

previous to a given seine haul. This is based on the assumption that as the number of seine hauls increases and the cumulative catch increases, the number of fish per haul will decrease.

5. Following this procedure, the data from the three seine hauls at a particular site were plotted and a line was fitted to these points using linear regression. The estimated number of fish at the site was then the point on the X-axis where this line intercepts it.

6. As the surface area and length of each sample site were measured, estimates were then placed on a numbers per surface acre and per stream mile basis for sake of comparison. With the weight data collected, standing crop estimates were also placed on a pounds per surface acre and per stream mile basis.

To allow additional comparisons to be made of the community structure of the fish populations present, the Shannon Index of Diversity, as described by Odum (1971), Wilhm (1967) and Wilhm and Dorris (1968), was applied to the data from each site. This index, based upon the formula

$$\bar{H} = -\Sigma \left[\left(\frac{ni}{N}\right) \log \left(\frac{ni}{N}\right) \right]$$

where $\bar{H}$ = Shannon index of general diversity

ni = importance value for each species

N = total of importance values

represents the wealth of individual types of organisms present (i.e., the number of different types and the number of each type present).

Benthic Invertebrates

Bottom fauna samples were collected at the Little Powder River study sites on three dates: June 12-13, 1974; August 20, 1974; and, October 31-November 1, 1974. On each date, six samples were taken from Sites No. 1 and 2, while due to the substrate variation, eight samples were collected at Site No. 3. Random number tables were employed to select sampling locations. One number was selected to determine the baseline marker stake at which the sample would be taken while a second number determined the sampling distance from the stream bank. Sampling locations are identified on Figures III-3, III-5 and III-7, pages III-6, III-11, and III-14, respectively.

According to the nature of the substrate, bottom samples were taken with either an Eckman dredge or a Surber Foot Square sampler. The Eckman dredge is a spring-operated, jaw type sampler especially designed for use in soft mud, muck and ooze substrates. Each sample encompasses an area of 0.25 square feet (0.023 m^2). At locations having a gravel substrate, the Surber sampler, which covers an area of 0.093 square meters, was used. Welch, 1949, discusses the use and operation of these samplers in greater detail. Table II-1 summarizes the sampling techniques used at the study sites.

All bottom fauna samples were transported live back to Laramie and immediately washed and screened. The detritus remaining in the screen was placed in white enamel pans and, using a 2X magnifying lamp, the invertebrates present were removed ("picked") and preserved in vials containing 95% alcohol. Each sample was then given a secondary "picking" for organisms overlooked during the first such operation.

TABLE II-1

BOTTOM SAMPLING TECHNIQUES USED AT THE LITTLE POWDER RIVER STUDY SITES

Date	Site No.	No. of Samples	Sampler Used	Total area sampled at Site (m^2)
June 12, 1974	1	6	Eckman	0.139
June 12, 1974	2	3	Eckman	0.348
	2	3	Surber	
June 13, 1974	3	5	Eckman	0.395
	3	3	Surber	
August 20, 1974	1	6	Eckman	0.139
	2	4	Eckman	0.279
	2	2	Surber	
	3	6	Eckman	0.325
	3	2	Surber	
November 1, 1974	1	6	Eckman	0.139
October 31, 1974	2	5	Eckman	0.209
	2	1	Surber	
November 1, 1974	3	4	Eckman	0.465
	3	4	Surber	

The benthic invertebrates were identified to the lowest taxonomic level possible using available keys (Pennak, 1953; Ward and Whipple, 1959). Most identifications were confirmed by Dr. Fred A. Lawson, Professor of Entomology at the University of Wyoming. The number of each taxonomic type present in each sample was then enumerated and the biomass of each individual organism was measured to the nearest milligram (mg) using a Mettler analytical balance. Immediately prior to weighing, all organisms were placed on filter paper and dried at room temperature for 24 hours. Thus, all weights were recorded as "air-dried" weights.

To allow comparisons of relative abundance to be made between both study sites and sampling times, bottom fauna data were placed on a numbers per 0.1 square meter and milligrams per 0.1 square meter basis. Also, Shannon Species Diversity Index values ($\bar{H}$) were calculated for each site at each time using the formula previously listed in this Chapter to facilitate comparisons of benthic community structure on both a numbers and biomass per 0.1 m^2 basis. To do this, $\bar{H}$ values were computed for each individual sample and these were then averaged to obtain the index number for a given study site at a given sampling time. Kruskal-Wallis Rank-Sum tests, as described by Dixon and Massey, 1969, were then used to determine if statistically significant differences existed between $\bar{H}$ values for the study sites and sampling times.

Water Quality

The water quality monitoring program for the Little Powder River study was designed to provide assessment data as a baseline condition before any upstream industrial activity. Three sampling points were selected for water quality sampling within the biological test section.

Basically, the water quality constituents specified for this project fall into three general categories for analysis. First, a cation-anion balance is determined as a guide for irrigation waters. Secondly, nutrients and organics are monitored to give an indication of waste load conditions.

Thirdly, the major trace metals are investigated for conditions assumed to be natural to the stream. In addition to the chemical constituent investigation, physical parameters are investigated as visual indicators of changes in the stream.

Samples of water were collected in the field and transported back to the Wyoming Department of Agriculture Chemical and Bacteriological Laboratory located on the University of Wyoming campus at Laramie. Water samples received at the laboratory were analyzed for the specified constituents by personnel supervised by Mr. Bob Freytag and with the able assistance of Mrs. Duaina Baldridge - WRRI graduate student. All laboratory methods were in accordance with "Standard Methods," thirteenth edition.

Field measurements were taken for streamflows, pH, specific conductance, dissolved oxygen, and temperature. The following

equipment was used:

I. Water temperature and specific conductance
   Yellow Springs Instrument Co., Inc.
   Yellow Springs, Ohio 45387
   Model 33 S-C-T
   Specific conductance, salinity and temperature (SCT) instrument

II. Dissolved Oxygen
   Yellow Springs Instrument Co., Inc.
   Yellow Springs, Ohio 45387
   Model 54 RC.
   Oxygen meter

III. Hydrogen ion (pH)
   Sargent-Welch Scientific Company
   Denver, Colorado 80207
   Model PBL
   pH meter

For convenience and consistency of sampling, sample bottles were prepared in Laramie with chemical preservations, tagged and boxed for transport to the field site. Table II-2 indicates the sample preservation and sample volume for each water quality constituent investigated.

TABLE II-2

SAMPLING AND TESTING TECHNIQUES USED FOR LITTLE POWDER RIVER WATER QUALITY SAMPLES

Water Quality Constituent	Type of Sample	Preservative	Location for Test	Notes
COD	Grab	H_2SO_4 to pH<2	Laramie	50ml
Nitrogen forms	Composite	$HgCl_2$	Laramie	1000 ml
Phosphorous	Composite	$HgCl_2$	Laramie	
Suspended Solids	Grab	Hold 4°C	Laramie	100ml
Metals	Grab	HNO_3 - pH to<2	Laramie	200 ml not filtered
Specific conductance	Grab	None	Field	
ph	Grab	None	Field	
Oil and Grease	Grab	H_2SO_4-4°C	Laramie	

CHAPTER III

DESCRIPTION OF STUDY AREA

The Basin

The Little Powder River is one of only several perennial streams occurring in Campbell County of northeastern Wyoming (Figure III-1). The topography is dominated by plains, low lying hills and table lands to the east with rough hills and gentle mountain ridges forming the west boundary of the basin. The Little Powder River is a major tributary of the Powder River within the Yellowstone River Basin of Wyoming. The headwaters rise in the Little Rawhide drainage (elevation 4800) immediately north of Gillette, Wyoming, and flow 88 miles to its confluence with the Powder River (elevation 3600) in southeast Montana. The total drainage area of the basin is 1,755 square miles.

The Little Powder River basin can be characterized primarily as a semiarid natural short grass plains area (average annual precipitation approximately 14 inches). Major vegetation types within the basin include: big sage brush (Artemisia tridentata), silver sage brush (Artemisia cana), black greasewood (Sarcobatus vermiculatus), ponderosa pine (Pinus ponderosa), plains cottonwood (Populus sargentii), and prairie grasses (Spartina pectinata, Deschampsia caespatesia, Elymus sp, and Agropyron sp). (Final Environmental Impact Statement, Eastern Powder River Coal Basin of Wyoming, October 18, 1974).

Coincident with this natural setting, major land uses in the past have included: 1) grazing lands for livestock; 2) production of native hay; and, 3) wildlife habitat for deer, pronghorn antelope and upland game birds. At present, industrial development is being planned in the

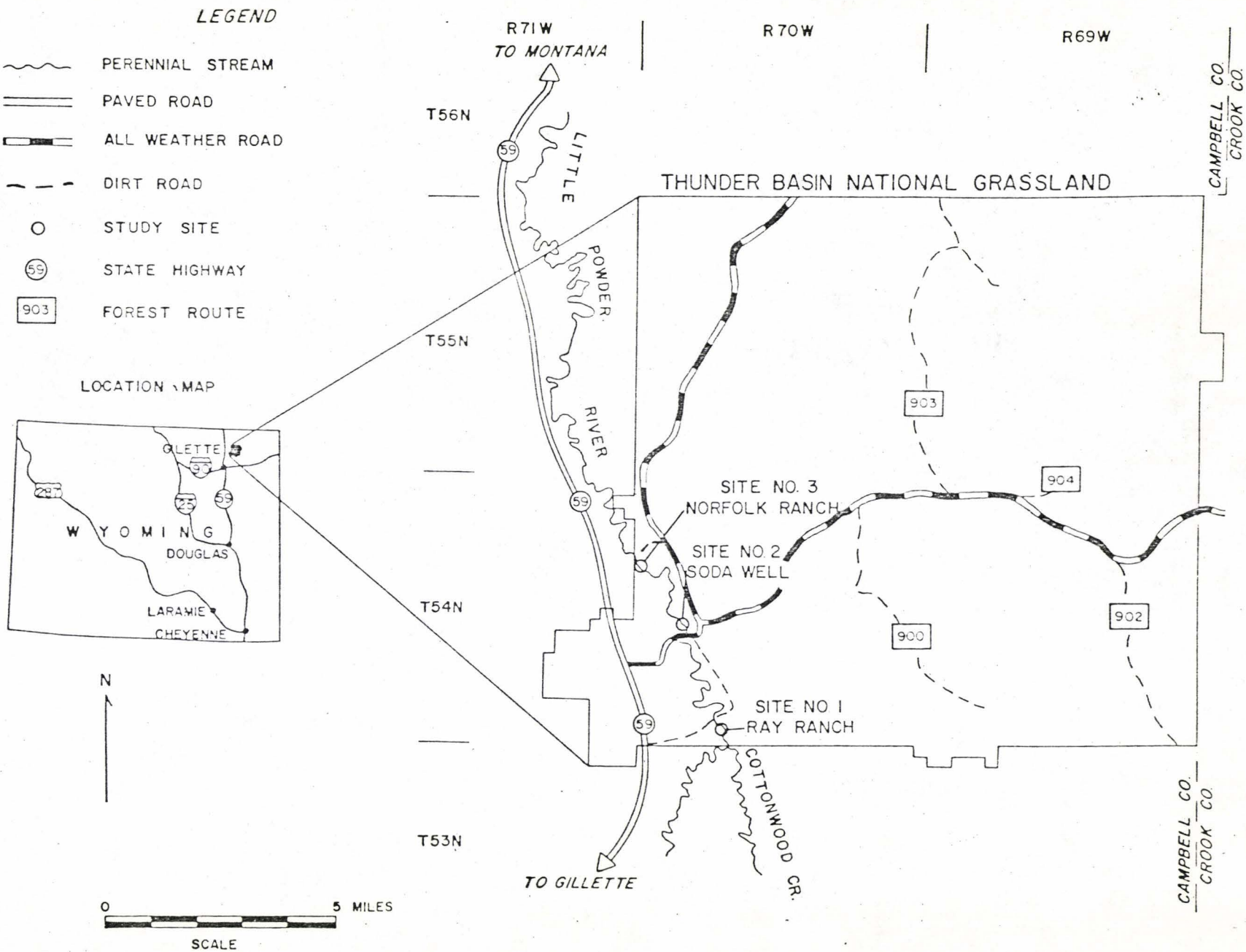

Figure III-1. Location Map of Little Powder River Study Sites in Wyoming

upper basin by 1975. Projects currently being discussed include strip mining for coal and water storage development.

The Little Powder River lies in the Fort Union Formation, tertiary rock of the Paleocene era. The formation is composed of three members:

1) The Tullock Member (lowermost)--950 to 1,300 feet thick--light gray to tan, even bedded sandstone (massive to thin); dark gray and brown siltstone; shale and carbonaceous shale; thin coal beds.

2) The Lebo Shale Member (middle)--1,700 to 2,800 feet thick where undifferentiated from the Tongue River Member--mostly medium and dark gray, fine-grained to conglomeratic sandstone; brownish carbonaceous shale; thin to thick coalbeds.

3) The Tongue River Member (uppermost)--800 feet thick--interbedded light gray, fine-grained sandstone; siltstone; sand; shale; coalbeds.

The coalbeds in the Tullock Member are thin and parted. However, the thick, persistent coalbeds located near the top of the formation in the eastern part of the basin are suitable for strip mining. (Final Environmental Impact Statement, Eastern Powder River Coal Basin of Wyoming, October 18, 1974). Oil and gas are other mineral resources found in the vicinity of the Little Powder River.

Streamflow records for the Little Powder River basin, as measured at U.S.G.S. Gage Station No. 06324970 located 20 miles north of Weston, Wyoming and five miles south of the Wyoming-Montana border, indicate that spring runoff occurs during late April, May and early June. A maximum discharge of 186 cfs (cubic feet per second) was measured on April 25, 1973, while periods of no flow were recorded during July and August of that year. During the remainder of the year, discharges normally remain below 5 cfs (U. S. Department of the Interior, 1973).

The Study Area

The study area was limited to the five mile section of the stream running across the southwest corner of the Thunder Basin National Grassland in Campbell County, Wyoming (Figure III-1, page III-2). The following sites were selected for study:

1) T 54 N, R 70 W, S 32--on the Loral Leaf Ranch owned by Mr. Frank Ray, one-quarter mile below the confluence of Cottonwood Creek near the south boundary of Thunder Basin (elevation 3,730 feet above msl).

2) T 54 N, R 70 W, S 19 and 20--immediately below the Soda Well bridge on Forest Service land (elevation 3,690 feet above msl).

3) T 54 N, R 70, S 7 and T 54 N, R 71 W, S 12--on the Norfolk Ranch at the west boundary of Thunder Basin (elevation 3,670 feet above msl).

Site No. 1

Above this site, the Little Powder River basin encompasses 472 square miles and is drained by 406 miles of perennial and intermittent stream channels (Figure III-2). Drainage density is 0.86. In this area, as well as at Sites No. 2 and 3, the Little Powder is a fifth order stream.

Site No. 1 was a 340-foot long straight reach covering 4530 square feet (Figure III-3). Hydraulically, this stream section was very homogenous. At the seven cross-channel transects, stream widths varied only from 12 to 13 feet, mean depths from 1.05 to 1.66 feet and mean velocity from 0.12 to 0.18 feet per second (Table III-1). Over 85 percent of the surface area was at least 1.0 foot in depth, as shown in Table III-2. Due to the flat gradient of the section (3.52 feet per

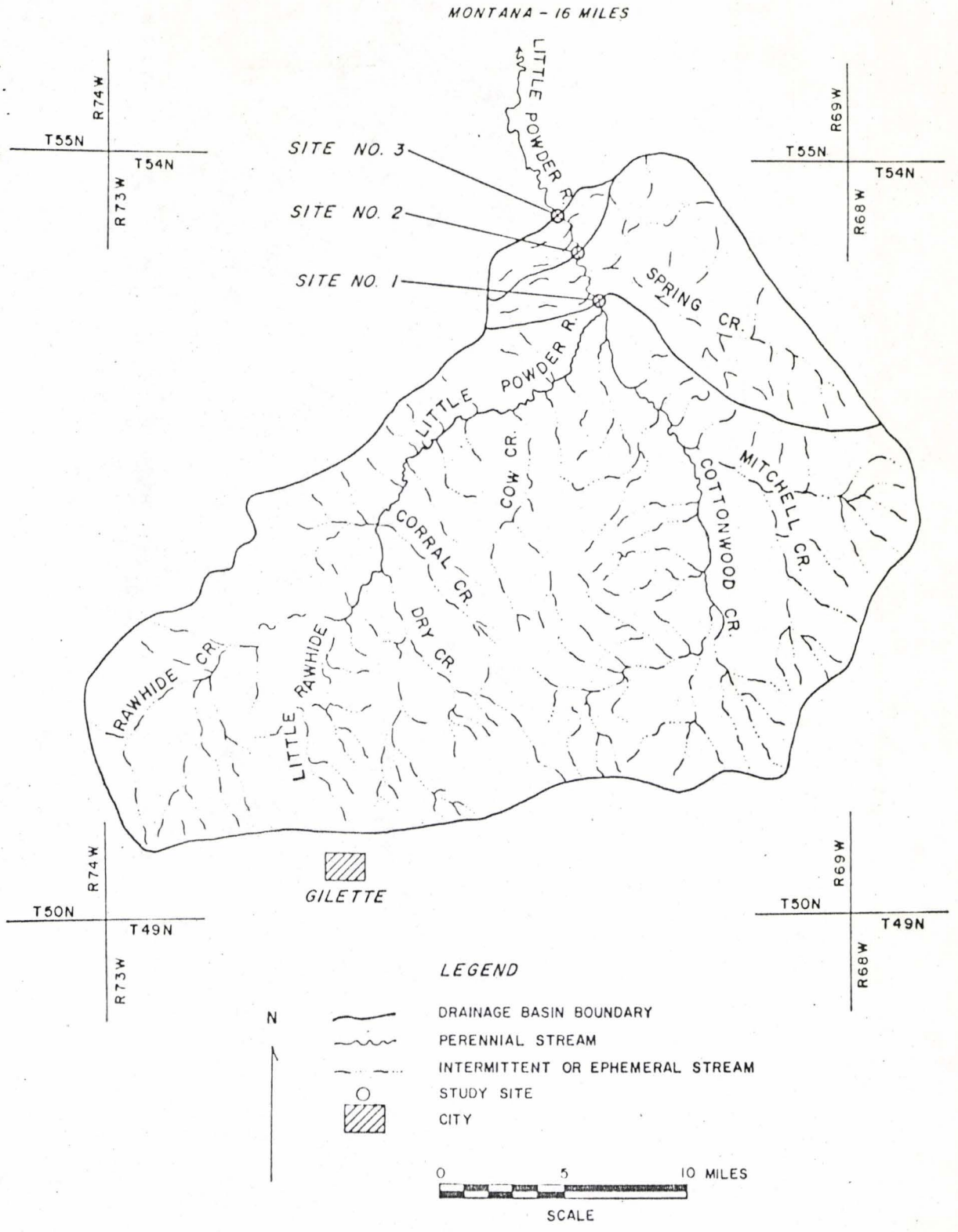

Figure III-2. Drainage Basin Map of the Little Powder River

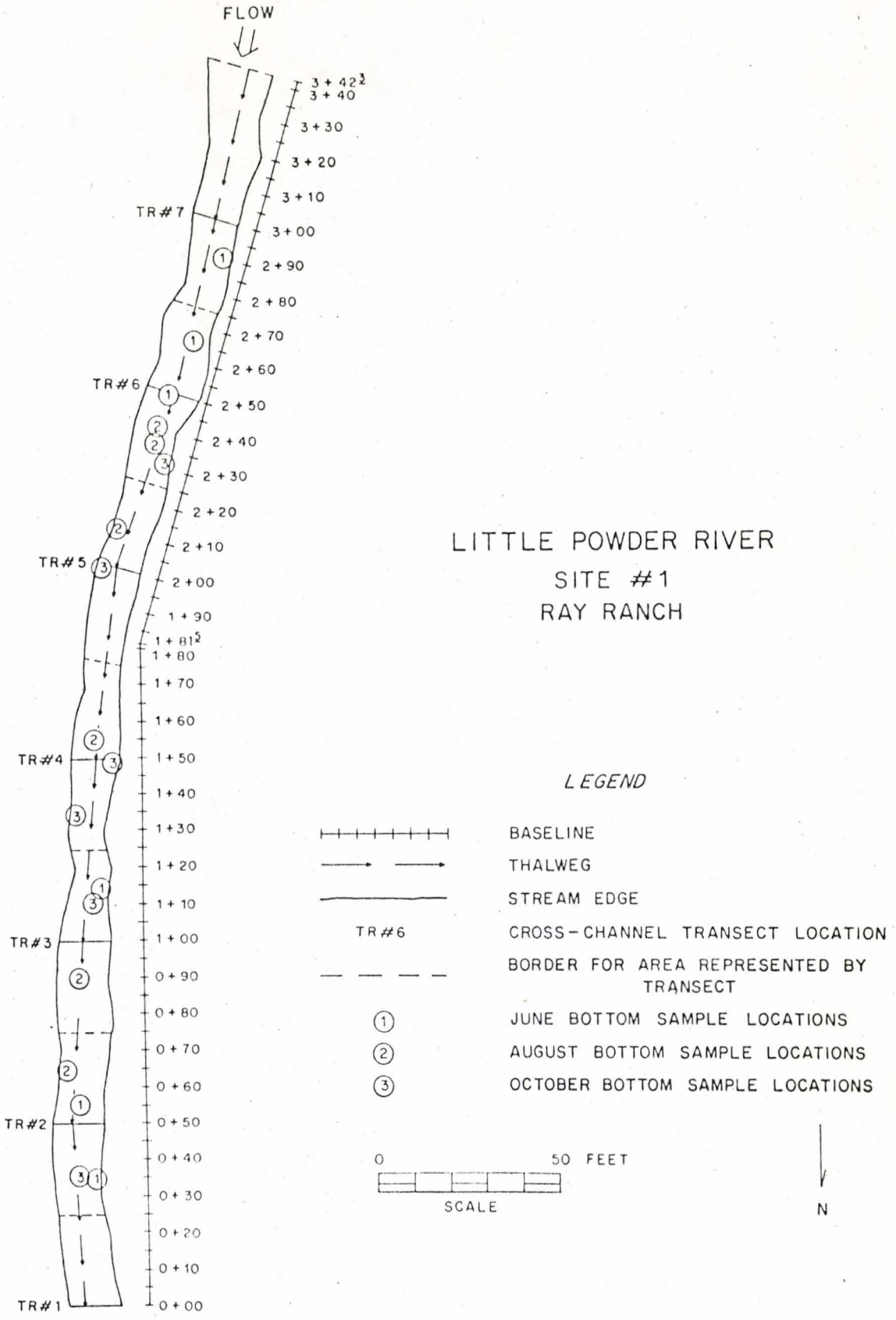

Figure III-3. Surface Area Map of Study Site No. 1

TABLE III-1

TRANSECT HYDRAULIC DATA AT THE THREE LITTLE POWDER RIVER STUDY SITES AT 2.4 CFS

Site	Top Width (ft)	Cross-Sectional Area (ft^2)	Mean Depth (ft)	Mean Velocity (ft/sc)
Site No. 1				
Tr. 1	13	13.7	1.05	0.18
Tr. 2	13	18.0	1.38	0.13
Tr. 3	13	14.1	1.08	0.17
Tr. 4	13	14.4	1.11	0.17
Tr. 5	12	19.9	1.66	0.12
Tr. 6	13	15.0	1.15	0.16
Tr. 7	12	17.1	1.42	0.14
Site No. 2				
Tr. 1	10	8.4	0.84	0.29
Tr. 2	8	7.8	0.98	0.31
Tr. 3	13	9.7	0.75	0.25
Tr. 4	12	15.6	1.30	0.15
Tr. 5	17	36.3	2.13	0.07
Tr. 6	16	33.0	2.07	0.07
Site No. 3				
Tr. 1	20	19.3	0.96	0.12
Tr. 2	19	16.1	0.85	0.15
Tr. 3	17	22.8	1.34	0.11
Tr. 4	23	13.1	0.57	0.18
Tr. 5	20	21.2	1.06	0.11
Tr. 6	8	3.6	0.45	0.67

TABLE III-2

SURFACE AREA COMPOSITION (FT^2) BY WATER DEPTH CLASS FOR THE THREE LITTLE POWDER RIVER STUDY SITES AT 2.4 CFS

Water Depth Class (Ft)	Surface Area - Ft^2 (% Total Area of Site) Site No. 1	Site No. 2	Site No. 3
<0.50	383 (8.5%)	169 (4.8%)	1195 (22.0%)
0.50 - 0.99	264 (5.8%	1005 (28.0%)	1930 (35.6%)
1.00 - 1.49	2274 (50.2%)	662 (18.4%)	1544 (28.5%)
≥1.50	1609 (35.5%)	1735 (48.8%)	752 (13.9%)
Total	4530 (100%)	3589 (100%)	5421 (100%)

mile), the substrate was composed entirely of inorganic muck, sediments which had settled out of the water. This, in conjunction with the steep streambanks which were present (range, 0.2:1 to 2.6:1), made access to and movement in the channel quite difficult during sample collection.

No aquatic vegetation was in evidence at Site No. 1, while along the streambanks and on the floodplain adjacent to the channel, grasses, sedges, sagebrush, greasewood and cottonwood tress were observed. The photographs found in Figure III-4 illustrate the vegetation and the physical features of the area. While sampling here, both mule deer and ring-necked pheasants were seen by the investigators.

Site No. 2

The Little Powder River watershed above Site No. 2 covers 542 square miles and is drained by a total of 459 miles of intermittent and perennial stream channels (Figure III-2, page III-5). The drainage density is 0.85.

In terms of channel hydraulics, this 270 foot long stream reach (3,589 square feet) showed greater diversity than did Site No. 1 (Figure III-5). Channel widths ranged from 8 to 17 feet, mean transect depths from 0.84 to 2.13 feet and mean velocities from 0.07 to 0.31 feet per second (Table III-1, page III-7). Approximately 67 percent of the surface area had water depths of 1.0 foot or greater (Table III-2, page III-8). The steeper gradient of Site No. 2 (7.39 feet per mile) accounted for the substrate variation found. Along the thalweg in the upper half of the area, water velocities were great enough to prevent sediment deposition. The substrate at these locations was primarily fine gravel (diameter up to ~1.5 inches), while in the quieter areas and in the entire lower half of the site, inorganic muck was the

Figure III-4. Little Powder River Study Site No. 1
Top left: Spring Top right: Summer
Bottom: Fall

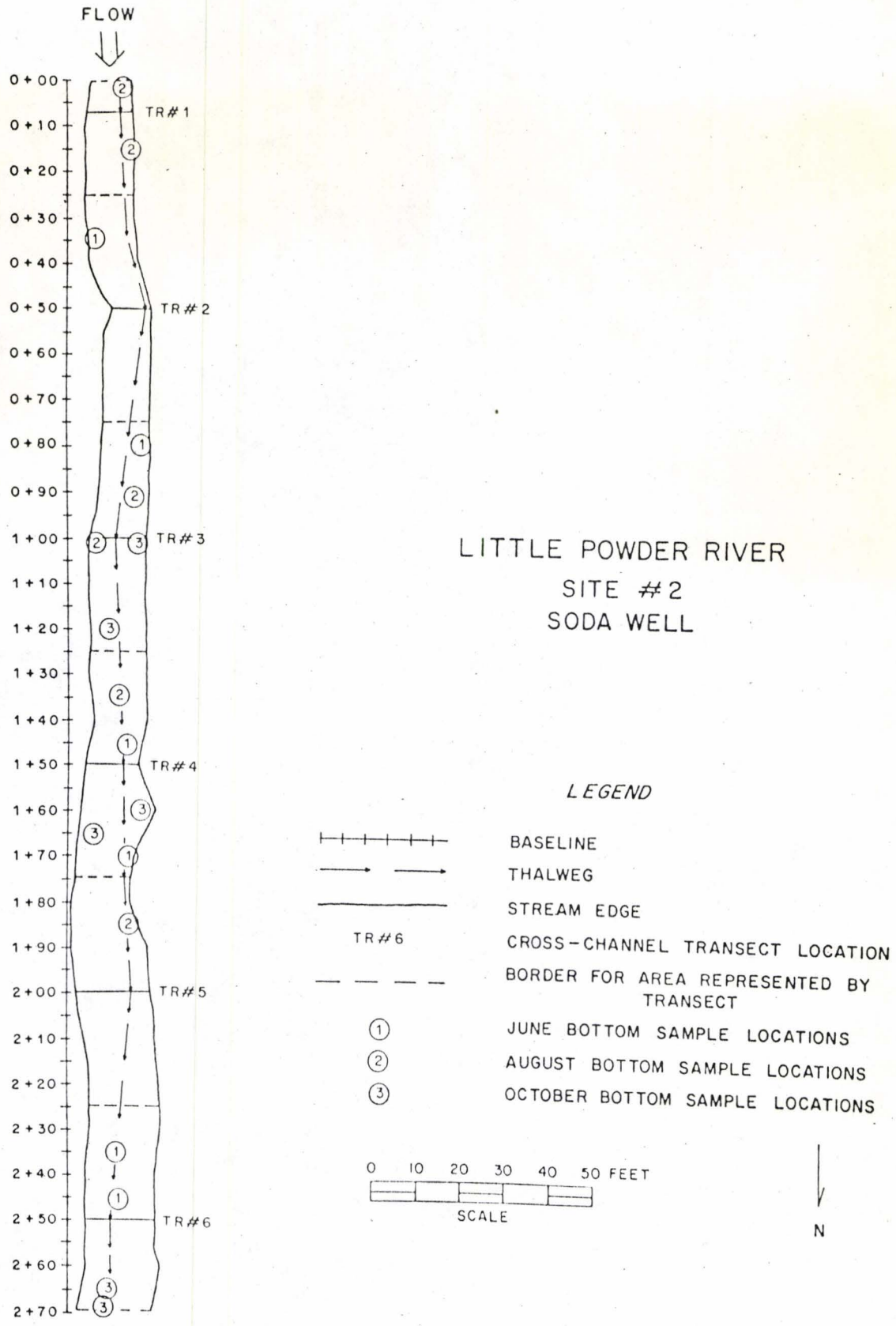

Figure III-5. Surface Area Map of Study Site No. 2

predominant substrate type. Bank slopes were not as steep at Site No. 2 as they were at Site No. 1, ranging from 1.8:1 to 4:1, thus accommodating easy stream access.

Aquatic vegetation at Site No. 2 was quite limited throughout the summer and fall, consisting only of several scattered patches of emergent reeds and sparse growths of filamentous green algae. Riparian vegetation was composed primarily of grasses and sedges, while the floodplain also had a moderately dense cover of sagebrush with scattered cottonwood trees. During the sampling periods, deer and racoon tracks were abundant in the area. The photographs in Figure III-6 illustrate the physical setting at Site No. 2.

Site No. 3

Between Sites No. 2 and 3, an additional 8.8 square miles of land are drained by 10.3 miles of stream channel, resulting in a drainage area of 551 square miles above this site containing a total of 469 miles of perennial and intermittent channels (Figure III-2, page III-5). Drainage density of the basin is 0.85.

Site No. 3 was a relatively straight stream reach 270 feet long having a surface area of 5,421 square feet (Figure III-7). Due to its steeper stream gradient (9.50 feet per mile) and greater channel widths (up to 23 feet), water depths at Site No. 3 were somewhat shallower (0.45 to 1.34 feet) than those at Sites 1 and 2, while mean velocities ranged higher, from 0.11 to 0.67 feet per second (Table III-1, page III-7). Approximately 58 percent of the surface area had water depths of less than 1.0 foot (Table III-2, page III-8). Substrate composition was similar to that found at Site No. 2. Along the thalweg in the upstream half of the study section, areas of fine gravel were found. The

Figure III-6. Little Powder River Study Site No. 2
Top left: Spring Top right: Summer
Bottom: Fall

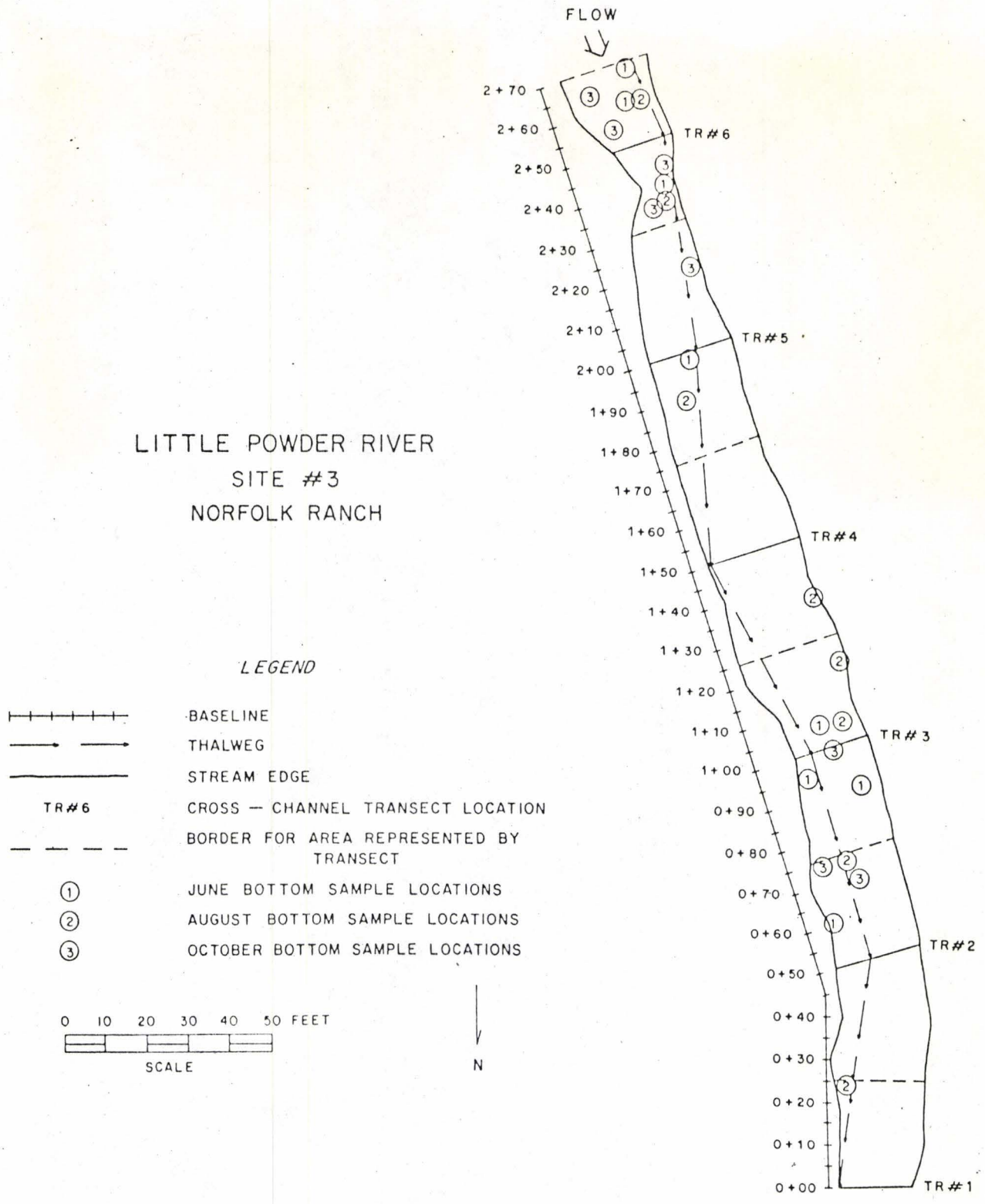

Figure III-7. Surface Area Map of Study Site No. 3

remainder of the substrate was of inorganic muck and sand. Bank slopes varied substantially at this site, ranging from 0.5:1 to 7.5:1.

As at Site No. 1, no aquatic vegetation was observed at this location. Grasses and sedges, interspersed with wild rose, grew along the streambanks, while the adjacent floodplain was primarily covered with grasses and scattered cottonwood trees. Deer and racoon tracks were abundant in the area. The photos in Figure III-8 illustrate the vegetation and physical aspects found at Site No. 3.

Figure III-8. Little Powder River Study Site No. 3
Top left: Spring Top right: Summer
Bottom: Fall

RESULTS

Biological

Fisheries

1974 Collections

Eleven species of fish, representing five families and three orders, were collected during the June, 1974 sampling of the three Little Powder River study sites. The taxonomic classification of these fishes is presented in Table IV-1. Of these eleven species, two are currently classified as game fish by the Wyoming Game and Fish Commission, the black bullhead and the green sunfish, while one species, the goldeye, is listed in Wyoming's Rare and Endangered Wildlife. At present, the status of the goldeye is "undetermined", meaning that the species has been suggested as possibly rare or endangered but there is not enough information available to determine its status.

From the literature and the files of the Wyoming Game and Fish Commission, little data is available concerning the fish populations of the Little Powder River in Wyoming. Baxter and Simon, 1970, reported collecting eleven fish species at three locations on the main stream (Table IV-2), while Wesche (1974), found no fish present in Little Rawhide Creek on the AMAX North Belle Ayr property, a tributary of the Little Powder. Three of the species collected by Baxter and Simon (plains minnows, mountain suckers and channel catfish) were not taken at the three study sites sampled by WRRI in 1974. However, the WRRI investigation did identify three additional species in this area, carp, goldeye and northern redhorse.

TABLE IV-1

TAXONOMIC CLASSIFICATION OF FISHES
COLLECTED FROM THE LITTLE POWDER RIVER

CLASS - OSTEICHTHYES (bony fishes)
SUBCLASS - ACTINOPTERYGII (ray-finned fishes)

Order	Family	Genus	Species
Clupeiformes	Hiodontidae (mooneyes)	Hiodon	alosoides (Rafinesque) (goldeye)
Cypriniformes	Cyprinidae (minnows)	Cyprinus	carpio (Linnaeus) (carp)
		Hybopsis	gracilis (Richardson) (flathead chub)
		Rhinichthys	cataractae (Valenciennes) (longnose dace)
		Notropis	stramineus missuriensis (Cope) (sand shiner)
		Pimephales	promelas (Rafinesque) (fathead minnow)
	Catostomidae (suckers)	Carpiodes	carpio (Rafinesque) (river carpsucker)
		Moxostoma	macrolepidotum (Lesueur) (northern redhorse)
		Catostomus	commersoni (Lacepede) (white sucker)
	Ictaluridae (North American catfishes)	Ictalurus	melas (Rafinesque) (black bullhead)
Perciformes	Centrarchidae (sunfishes)	Lepomis	cyanellus (Rafinesque) (green sunfish)

TABLE IV-2

FISH SPECIES OF THE LITTLE POWDER RIVER
AS REPORTED BY BAXTER - SIMON, 1970*

Family	Genus	Species	Common Name
Cyprinidae	[1]Hybopsis	gracilis (Richardson)	Flathead Chub
	[1]Rhinichthys	cataractae (Valenciennes)	Longnose Dace
	[1]Notropis	stramineus missuriensis (Cope)	Sand Shiner
	[1]Hybognathus	placitus (Girard)	Plains Minnow
	[1]Pimephales	promelas (Rafinesque)	Fathead Minnow
Catostomidae	[1]Catostomus	commersoni (Lacépède)	White Sucker
	[1]Catostomus	platyrhynchus (Cope)	Mountain Sucker
	[1]Carpiodes	carpio (Rafinesque)	River Carpsucker
Ictaluridae	[1]Ictalurus	melas (Rafinesque)	Black Bullhead
	Ictalurus	punctatus (Rafinesque)	Channel Catfish
Centrarchidae	[1]Lepomis	cyanellus (Rafinesque)	Green Sunfish

*From: Wyoming Fishes, Baxter - Simon, 1970.

[1]Species collected by WRRI, 1974.

Seven species of fish were collected at Site No. 1, five at Site No. 2 and eleven at Site No. 3. The species compositon and length-weight data for each site are presented in Table IV-3, while the percentages of the populations comprised by each species, on both a numbers and a weight basis, are provided in Table IV-4. As shown, the predominant species found in this area of the Little Powder River, by numbers, was the sand shiner. Its abundance ranged from 60.8 percent of the total population at Site No. 1 up to 75.7 percent at Site No. 3. However, this small minnow species comprised less than 20 percent of each population on a weight basis. White suckers were the predominant species, by weight, at Sites No. 1 and 2 (47.6 and 40.9 percent respectively), while at No. 3, green sunfish comprised 26.2 percent of the biomass. The one goldeye collected accounted for less than one percent of the numbers at No. 3, but 25.8 percent of the biomass.

Standing crop estimates for the fish populations present at the three Little Powder River sites are presented in Table IV-5. Shannon species diversity index values for each site are shown in Table IV-6. On the June sampling date, the densest population of fish, on a surface acre basis, was found at Site No. 1 (2,971 fish per acre), while on a stream mile basis, Site No. 3 had the greatest concentration (6,562 per mile). In terms of biomass, Site No. 1 standing crop estimates were the largest, with 66.8 pounds per acre and 106.5 pounds per mile. Species diversity values based on numbers of fish at each site were greatest at Site No. 1; however, when considering biomass, community structure at Site No. 3 was the most diverse.

No data is available from the Wyoming Game and Fish Commission concerning angler use and success on the Little Powder River within the

TABLE IV-3

LENGTH-WEIGHT DATA FOR FISH SPECIES COLLECTED FROM LITTLE POWDER RIVER ON JUNE 12 and 13, 1974

Species	Number	Mean Length (mm)	Length Range (mm)	Mean Weight (g)	Mean Range (g)
		Site No. 1			
Black Bullhead	25	98.3	35.6-185.4	26.0	1.0-96.0
Green Sunfish	22	71.6	27.9-134.6	10.9	1.0-48.0
White Sucker	28	146.6	58.4-264.2	39.6	1.0-147.0
Carp	2	130.8	106.7-154.9	37.5	20.0-55.0
Fathead Minnow	11	63.0	48.3-71.1	3.2	1.0-5.0
Sand Shiner	138	51.8	33.0-63.5	1.5	1.0-3.0
Longnose Dace	1	53.3	——	1.0	——
		Site No. 2			
Black Bullhead	17	54.1	35.6-142.2	3.6	1.0-36.0
Green Sunfish	17	54.9	33.0-144.8	7.9	1.0-66.0
White Sucker	4	169.7	154.9-180.3	49.2	37.0-56.0
Fathead Minnow	2	62.2	61.0-63.5	2.0	——
Sand Shiners	80	46.0	27.9-55.9	1.0	0.5-2.0
		Site No. 3			
Black Bullhead	11	77.5	45.7-180.3	10.8	1.0-71.0
Green Sunfish	23	70.9	30.5-139.7	14.7	1.0-62.0
White Sucker	8	112.3	81.3-144.8	16.0	6.0-30.0
River Carpsucker	2	138.4	134.6-142.2	38.0	34.0-42.0
Northern Redhorse	5	78.7	58.4-114.3	5.4	2.0-14.0
Carp	1	104.1	——	20.0	——
Fathead Minnow	15	52.1	40.6-68.6	1.7	1.0-4.0
Sand Shiners	233	38.1	25.4-50.8	0.8	0.5-2.0
Longnose Dace	5	52.3	50.8-55.9	1.0	——
Flathead Chub	4	94.5	66.0-127.0	9.0	2.0-20.0
Goldeye	1	330.2	——	333.0	——

TABLE IV-4

SPECIES COMPOSITION OF FISH POPULATIONS AT THE LITTLE POWDER RIVER STUDY SITES EXPRESSED AS PERCENT OF TOTAL NUMBERS AND WEIGHT

Species	Percent Total Numbers and Weight					
	Site #1		Site #2		Site #3	
	% Numbers	% Weight	% Numbers	% Weight	% Numbers	% Weight
Black Bullhead	11.0	28.0	14.3	13.0	3.6	9.4
Green Sunfish	9.7	10.3	14.3	28.5	7.5	26.2
White Sucker	12.3	47.6	3.3	40.9	2.6	9.8
River Carpsucker	0	0	0	0	0.6	5.9
Northern Redhorse	0	0	0	0	1.6	1.9
Carp	1.0	3.6	0	0	0.3	1.5
Fathead Minnow	4.9	1.5	1.6	1.0	4.9	1.9
Sand Shiner	60.8	9.0	66.5	16.6	75.7	14.5
Longnose Dace	0.3	<0.1	0	0	1.6	0.4
Flathead Chub	0	0	0	0	1.3	2.7
Goldeye	0	0	0	0	0.3	25.8
Total	100%	100%	100%	100%	100%	100%

TABLE IV-5

STANDING CROP ESTIMATES FOR FISH SPECIES COLLECTED AT THE THREE LITTLE POWDER RIVER SAMPLING SITES JUNE 12 and 13, 1974

SPECIES	Site No. 1		Site No. 2		Site No. 3	
	No./acre (No./mile)	Pounds/acre (Pounds/mile)	No./acre (No./mile)	Pounds/acre (Pounds/mile)	No./acre (No./mile)	Pounds/acre (Pounds/mile)
Black Bullhead	327 (520)	18.7 (29.8)	316 (507)	2.5 (4.0)	99 (234)	2.4 (5.7)
Green Sunfish	288 (459)	6.9 (11.0)	316 (507)	5.5 (8.8)	207 (489)	6.7 (15.8)
White Sucker	365 (582)	31.8 (50.8)	73 (117)	7.9 (12.7)	72 (170)	2.5 (5.9)
River Carpsucker	0 (0)	0 (0)	0 (0)	0 (0)	18 (43)	1.5 (3.5)
Northern Redhorse	0 (0)	0 (0)	0 (0)	0 (0)	45 (106)	0.5 (1.2)
Carp	29 (46)	2.4 (3.8)	0 (0)	0 (0)	9 (21)	0.4 (0.9)
Fathead Minnow	144 (230)	1.0 (1.6)	36 (58)	0.2 (0.3)	135 (319)	0.5 (1.2)
Sand Shiner	1808 (2877)	6.0 (9.5)	1468 (2357)	3.2 (5.2)	2098 (4958)	3.7 (8.7)
Longnose Dace	10 (15)	0.02 (0.03)	0 (0)	0 (0)	45 (106)	0.1 (0.2)

TABLE IV-5 (Cont.)

STANDING CROP ESTIMATES FOR FISH SPECIES COLLECTED
AT THE THREE LITTLE POWDER RIVER SAMPLING SITES
JUNE 12 and 13, 1974

SPECIES	Site No. 1		Site No. 2		Site No. 3	
	No./acre (No./mile)	Pounds/acre (Pounds/mile)	No./acre (No./mile)	Pounds/acre (Pounds/mile)	No./acre (No./mile)	Pounds/acre (Pounds/mile)
Flathead Chub	0 (0)	0 (0)	0 (0)	0 (0)	36 (85)	0.7 (1.7)
Goldeye	0 (0)	0 (0)	0 (0)	0 (0)	9 (21)	6.6 (15.6)
Total	2971 (4729)	66.8 (106.5)	2209 (3546)	19.3 (31.0)	2773 (6552)	25.6 (60.4)

TABLE IV-6

SHANNON SPECIES DIVERSITY INDEX VALUES ($\bar{H}$) FOR THE FISH POPULATIONS SAMPLED AT THE THREE LITTLE POWDER RIVER STUDY SITES ON JUNE 12 and 13, 1974

	Site No. 1	Site No. 2	Site No. 3
$\bar{H}$ (No. fish/surface acre)	0.538528	0.437629	0.445463
$\bar{H}$ (Pounds fish/surface acre)	0.411384	0.579120	0.839926

boundaries of Thunder Basin National Grassland (Mueller, 1974 personal communication). As previously stated, two game fish species, green sunfish and black bullheads, were collected. From the length-frequency distributions shown in Figures IV-1 and IV-2, it is evident that catchable size representatives of these species are present. However, the extent to which local residents of the area fish for them is unknown. Baxter and Simon, 1970, reported collecting channel catfish in the Little Powder near the Wyoming-Montana border. This game fish species, however, was not collected within Thunder Basin in 1974. While goldeye are not considered a game fish species, local residents did report that in years past limited angling for this species did occur, primarily in the vicinity of Site No. 3.

Biology of Species Collected

Green Sunfish (Lepomis cyanellus)

(From: Baxter and Simon, 1970; Scott and Crossman, 1973; Hunter, 1963.)

Adult Size: Approximately eight inches.

Life Expectancy: seven to nine years.

Range: Widely distributed in the U. S., from the Great Lakes to the Mexican Border and from the Alleghenies to the Rocky Mountains. In Wyoming, primarily in the northeastern counties and also in the North Platte, Big Horn and Niobrara river systems.

Preferred Habitat: Pools of small and medium sized streams. Sometimes abundant in small lakes, ponds and sloughs.

Feeding Habits: Carnivorous, feeding primarily on insects, molluscs and small fishes.

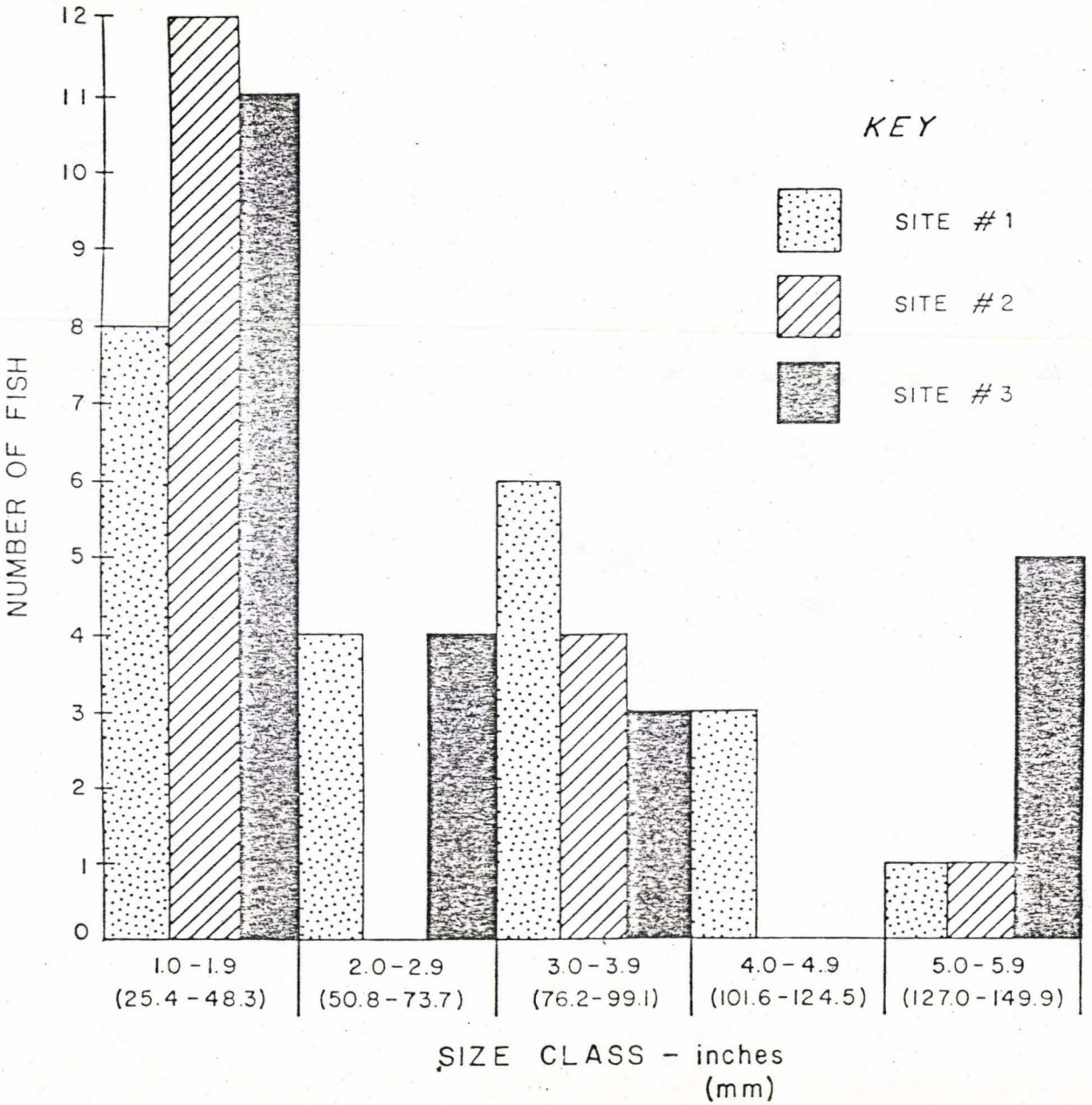

Figure IV-1. Length-Frequency Distribution of Green Sunfish Collected From the Little Powder River.

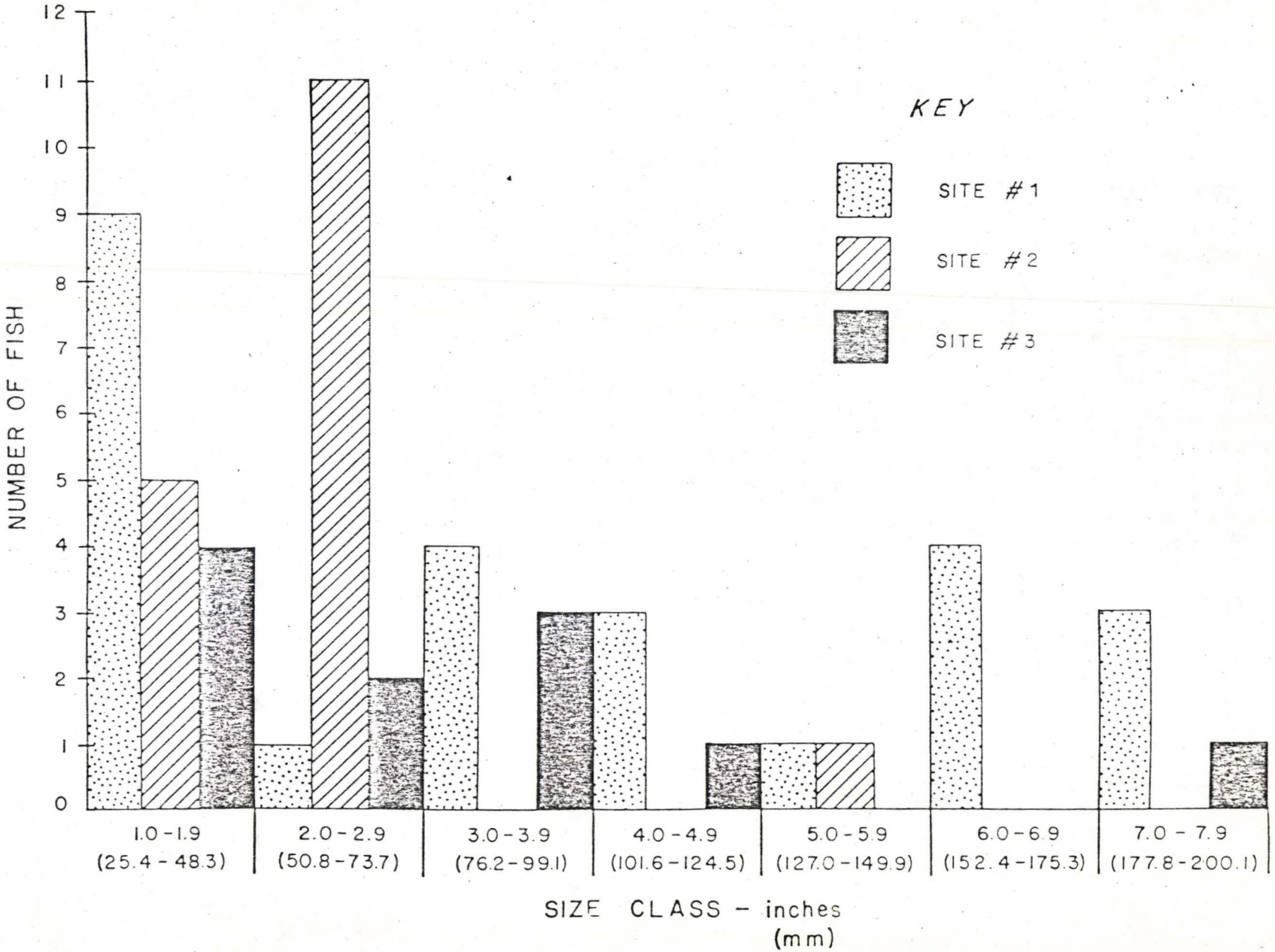

Figure IV-2. Length-Frequency Distribution of Black Bullheads Collected From the Little Powder River

Spawning Habits: Individuals reach sexual maturity at two to three years of age. Spawning normally occurs during the spring and early summer (68 to 83°F) over substrates of mud, silt, sand or aquatic vegetation in pools having water depths ranging from 1.5 to 18 inches. Eggs are deposited in a nest built by the male and hatch in three to five days. Members of the species are prolific spawners and often overpopulate their warm water habitats.

Comments: At the Little Powder River study sites, it appeared that spawning had occurred prior to the June sampling and the eggs had hatched. This was indicated by the number of fish in the 1.0 to 1.9 inch size group, as shown on Figure IV-1, page IV-11.

Black Bullhead (Ictalurus melas)

(From: Baxter and Simon, 1970; Scott and Crossman, 1973; Forney, 1955; Wallace, 1967; Black, 1953.)

Adult Size: Average five to seven inches, but up to 15 inches.

Life Expectancy: Approximately nine years.

Range: From the East coast west to the Rocky Mountains and from Manitoba south to Tennessee. In Wyoming, found in all drainages east of the Continental Divide on the plains. Species can tolerate water temperatures to mid-90°F range and very low dissolved oxygen concentrations.

Preferred Habitat: Low gradient, turbid, warmwater streams and ponds.

Feeding Habits: Primarily carnivorous, including aquatic insects, snails, crustaceans and small fish. Also feed on plant material.

Spawning Habits: Spawning normally occurs during the spring and early summer (approximately 70°F) in shallow pool areas having substrates of mud, silt, sand or rooted aquatic vegetation. Each mating pair builds at least five nests, with approximately 200 eggs deposited in each. Eggs hatch in five days and the fry are guarded by one or both parents. Members of this species are prolific spawners and often overpopulate their habitat unless intensively managed as a fishery.

Comments: At the Little Powder River study sites, it appeared that spawning had occurred prior to the June sampling and the eggs had hatched. This was indicated by the number of fish collected in the 1.0 to 1.9 inch size class (Figure IV-2, page IV-12).

Goldeye (Hiodon alosoides)

(From: Baxter and Simon, 1970; Scott and Crossman, 1973; Kennedy and Sprules, 1967; Battle and Sprules, 1960; McPhail and Lindsey, 1970.)

Adult Size: Average one pound or less in Wyoming.

Life Expectancy: Individuals reported to 15 years.

Range: From Saskatchewan through the Missouri and Mississippi drainages east to Ohio and south to Tennessee, Oklahoma and Texas. In Wyoming, formerly found in the North Platte, Big Horn, Powder and Little Missouri river drainages. Found only in the lower Powder River, Clear Creek and Little Missouri River during recent collections.

Preferred Habitat: Quiet, turbid water of larger rivers, the small lakes, ponds and marshes connected to them, and also in muddy shallows of larger lakes. Large eyes adapt it to turbid conditions.

Feeding Habits: Carnivorous, including insects, fish and frogs. Juveniles feed primarily on zooplankton.

Spawning Habits: Spawning normally occurs in the pools of turbid rivers and backwater lakes and ponds during the spring and early summer when water temperatures reach the 50 to 55°F range. In Manitoba, females averaged 14,150 eggs each. Fertilized eggs are semi-buoyant and float in the current. Thus, no nest is built and no parental care is exhibited. Eggs hatch in about two weeks.

Comments: In Wyoming, young goldeye have never been collected and no data is available regarding spawning habits. Species are not classified as a game fish in Wyoming; however, in Canada it is considered a valuable food fish.

Sand Shiner (Notropis stramineus missuriensis)

(From: Baxter and Simon, 1970; Scott and Crossman, 1973; Minckley, 1973; Carlander, 1969; Starret, 1951.)

Adult Size: Normally two to three inches.

Life Expectancy: Three to four years.

Range: Rocky Mountains east to the St. Lawrence drainage. In Wyoming, all drainages east of the Continental Divide, except the headwaters of the Madison and Yellowstone rivers in Yellowstone Park.

Preferred Habitat: Warm, perennial, sandy streams and sandy, shallow lakes with little rooted aquatic vegetation.

Feeding Habits: Omnivorous, including aquatic and terrestrial insects and diatoms.

Spawning Habits: Individuals normally become sexually mature at one year of age. Spawning occurs in the summer from June to August over sand and clean gravel areas. Each female produces from 250 to 3,000 eggs which are scattered over the stream substrate. No nest construction or parental care is known to occur.

Comments: Excellent forage species in Wyoming. No spawning activity or gravid specimens were noted during WRRI's 1974 collections.

Fathead Minnow (Pimephales promelas)

(From: Baxter and Simon, 1970; Markus, 1934; Simpson, 1941; Scott and Crossman, 1973; Wynne-Edwards, 1932.)

Adult Size: Up to 3.5 inches.

Life Expectancy: Normally two years.

Range: Northwest Territory of Canada south to Mexico, east of the Rocky Mountains. In Wyoming, widespread and common in smaller streams, many ponds and some lakes east of the Continental Divide. Has been introduced into the Green River drainage.

Preferred Habitat: Cool and warmwater, slow-flowing, weedy streams and shallow lakes and ponds. Common in many intermittent streams.

Feeding Habits: Primarily herbivorous, including algae, plankton and organic detritus. Also, small numbers of insects.

Spawning Habits: In more northerly climates, individuals reach sexual maturity at one year of age; however, in Iowa, it was found that fish hatched in May reach adult size and were spawning by late July. Spawning activity normally begins in

spring or early summer when water temperatures reach 60°F. Males select and guard nests located in rocky or weedy areas (also under logs) of pools in one to three feet of water. Females then deposit up to 12,000 adhesive eggs which cling to the roof of the nest. The incubation period ranges from four to six days. During this phase of development, the male guards the eggs and agitates the water in the near vicinity of them. This agitation prevents silt accumulations, removes metabolic products and aerates the eggs.

Comments: At the Little Powder River study sites in June, examination of adult fish revealed that most spawning activity had already occurred, although several individuals, still gravid, were collected. This species serves as an excellent forage fish throughout the U. S.

Carp (Cyprinus carpio)

(From: Baxter and Simon, 1970; Scott and Crossman, 1973.)

Adult Size: Seldom over 10 pounds in Wyoming.

Life Expectancy: Up to 20 years.

Range: Throughout U. S. In Wyoming, common at lower elevations in all river systems except the Snake and Niobrara rivers.

Preferred Habitat: Lakes, lagoons and quiet pools and backwaters of rivers.

Feeding Habits: Omnivorous. Species "roots" in bottom muds for insects, annelids, molluscs, crustaceans and vegetation.

Spawning Habits: Maturity is normally reached in three to four years for males, while for females, four to five years. Spawning occurs in the spring and early summer when water

temperatures range from 63 to 82°F in the shallow, weedy areas of pools. Carp are extremely prolific, with large females capable of producing up to several million adhesive eggs. No nests are built and no parental care is exhibited. Eggs are scattered over the bottom where they adhere to vegetation and incubate for three to six days before hatching.

Comments: During the June sampling on the Little Powder, no gravid individuals were collected. Two explanations can be offered for this; either spawning had already occurred, or, the three individuals captured had not yet reached sexual maturity. This species is normally considered detrimental to game fish because their "rooting" while feeding increases turbidity and destroys vegetation.

Flathead Chub (Hybopsis gracilis)

(From: Baxter and Simon, 1970; Olund and Cross, 1961; Cross, 1967; Scott and Crossman, 1973.)

Adult Size: Average five to seven inches. Up to 10 inches or more.

Life Expectancy: Several years.

Range: From the Northwest Territory of Canada south to Oklahoma and New Mexico. In Wyoming, common in all drainages east of the Continental Divide except the Madison, Yellowstone, Niobrara and South Platte river systems.

Preferred Habitat: Larger silty rivers. Seldom found in lakes and ponds.

Feeding Habits: Primarily carnivorous, including terrestrial and aquatic insects and small fish. Also some vegetation.

Spawning Habits: Species apparently spawns relatively late in summer when rivers are lower, warmer and the bottom more stable. No other information is available except that males become tuberculate in late summer.

Comments: Two of the four individuals collected from the Little Powder in June were females in pre-spawning condition.

Longnose Dace (Rhinichthys cataractae)

(From: Baxter and Simon, 1970; Kuehn, 1949; Simpson, 1941; McPhail and Lindsey, 1970; Scott and Crossman, 1973.)

Adult Size: Average three to four inches. Up to six inches.

Life Expectancy: Up to five years.

Range: Throughout U. S. In Wyoming, native to and common in all drainages but the Green and Little Snake River basins.

Preferred Habitat: Both small and large streams in riffle areas. Also found in lakes along rocky shorelines.

Feeding Habits: Primarily insectivorous, but also feed on small amounts of algae.

Spawning Habits: Spawning occurs in the spring and summer most probably in riffle areas over a gravel bottom. Each female normally produces from 200 to 1,200 adhesive eggs which cling to the substrate. No nest is built but one parent remains in the vicinity of egg deposition to guard them. At 60^{o}F, eggs hatch in seven to ten days.

Comments: None of the six collected were found to be gravid, indicating that spawning had already occurred or that the specimens were juvenile fish (length range 2.0 to 2.2 inches, Table IV-3). Few individuals were collected during June sampling,

most probably due to the lack of gravel bottomed riffle areas which this species prefers.

White Sucker (Catostomus commersoni)

(From: Baxter and Simon, 1970; Reighard, 1920; Simpson, 1941; Scott and Crossman, 1973; Campbell, 1935; Geen et al, 1966.)

Adult Size: Rarely over two pounds in Wyoming.

Life Expectancy: Up to 17 years.

Range: Rocky Mountains east to Atlantic seacoast and south from the Arctic Circle to southeastern U. S. In Wyoming, most common fish east of the Continental Divide. Also been introduced into Green and Little Snake River drainages.

Preferred Habitat: Common in a variety of habitats, from high mountain lakes to sluggish lowland streams. Avoids fast current.

Feeding Habits: Omnivorous. Feeds along stream bottom primarily for insects, but also for algae and other organic debris.

Spawning Habits: Individuals normally mature from three to four years of age. Spawning activity begins in spring and early summer when water temperatures reach 50^{o}F in shallow water over sand or gravel substrates. During spawning the males become densely tuberculate. There is no deliberate construction of a nest but the activities of the adults create depressions in the substrate into which the female may deposit up to 50,000 eggs. The incubation period lasts approximately 14 days.

Comments: At the Little Powder River sites in June, spawning had already occurred as no gravid adults were collected. This species serves as a good forage fish.

Northern Redhorse (Moxostoma macrolepidotum)

(From: Baxter and Simon, 1970; Scott and Crossman; Meyer, 1962; Reed, 1962.)

Adult Size: Up to 20 inches and several pounds.

Life Expectancy: Reported up to 12 years.

Range: Montana and Saskatchewan east to Atlantic seacoast and south to Oklahoma. In Wyoming, species had previously been collected in the North Platte and lower Laramie Rivers, in the Belle Fourche, Tongue and Powder River drainages, and in the Big Horn River.

Preferred Habitat: Medium sized streams and lakes with cool, clear water.

Feeding Habits: Primarily insectivorous, feeding on midges, mayflies and caddisflies. Strain invertebrate from bottom material.

Spawning Habits: In Iowa, individuals have been reported to become sexually mature at three years of age. Spawning occurs in the spring when water temperatures reach $52^{o}F$ in shallow water over sand or gravel substrates. As with white suckers, there is no deliberate nest construction. Females produce up to 30,000 eggs, which are scattered over the stream bottom and then abandoned.

Comments: Of the five individuals collected in June at the Little Powder River Site No. 3, none were gravid. As all were less than five inches in length, these were most probably juvenile fish (Table IV-3, page IV-5).

River Carpsucker (Carpiodes carpio)

(From: Baxter and Simon, 1970; Scott and Crossman, 1973; Harlan and Speaker, 1951; Deacon, 1961; Buchholz, 1957.)

Adult Size: Up to 10 pounds in Wyoming.

Life Expectancy: Unknown.

Range: From Montana to Pennsylvania and south to Tennessee and Texas. In Wyoming, found in the Big Horn, Powder, Little Powder, Belle Fourche, and North Platte river basins.

Preferred Habitat: Quiet pools in clear and turbid streams, but not common in rubble-bottomed streams.

Feeding Habits: Primarily herbivorous, but also some small invertebrates.

Spawning Habits: Spawning occurs from April to June with the eggs being scattered over the stream bottom and left unattended.

Comments: During the June sampling at Little Powder River Site No. 3 neither of the two individuals collected were gravid. Either spawning had previously occurred or these were juvenile forms (both were less than six inches in length, Table IV-3, page IV-5).

Benthic Invertebrates

The benthic invertebrates collected at the Little Powder River study sites were found to represent 3 phyla, 6 classes, 12 orders, 19 families and at least 26 genera. Table IV-7 presents the taxonomic classification of these organisms, while Tables IV-8, IV-9 and IV-10 summarize the bottom fauna data obtained at Sites No. 1, 2 and 3, respectively. The relative abundance of invertebrates at each site by sample date are shown on a numbers per 0.1 m^2 basis in Table IV-11 and for biomass, in Table IV-12. General trends in relative abundance are illustrated in Figure IV-3.

Site No. 1

On all sample dates, oligocheates (aquatic worms) were the predominant organisms on both a numbers and a biomass basis at Site No. 1. Mean number ranged from 20.9 (June 12 and August 20) up to 101.4 per 0.1 m^2 (November 1), while mean biomass varied from 0.9 mg per 0.1 m^2 on August 20 up to 33.9 on November 1 (Tables IV-11 and IV-12). On a percent basis, oligocheates comprised from 67.5% to 74.3% of the total numbers collected and from 39.4% to 67.2% of the biomass (Table IV-8). Other forms found to be quite common were Diptera larvae, mayfly nymphs (g. Caenis), and aquatic beetles, both adults and larvae.

The relative abundance of bottom fauna appeared to remain quite stable between the June and August samplings, with an increase in density noted in the November samples (Figure IV-3). This trend paralleled closely that shown by the oligocheates. Possible explanations for the fall increases would be the cessation of predation by the fish population due to cooler water temperatures and the development of juvenile invertebrates later in the season. Also, in past sampling,

TABLE IV-7

TAXONOMIC CLASSIFICATION OF BENTHIC FAUNA FROM THE LITTLE POWDER RIVER

Phylum	Class	Order	Family	Genus
Arthropoda	Insecta	Ephemeroptera (mayfly)	Caenidae	Caenis sp
		Coleoptera (beetles)	Elmidae	Dubiraphia sp.
			Hydrophilidae	Helophorus sp
			Haliplidae	Brychius sp.
		Diptera (two-winged flies)	Ceratopogonidae	Probezzia sp.
				Palpomyia sp.
			Chironomidae	Pentaneura sp.
				Chironomus sp.
			Tabanidae	Tabanus sp.
				Haematopota sp.
				Chrysops sp.
		Odonata (damsel and dragon flies)	Coenagroinidae	Argia sp.
				Chromagroin sp.
				Amphiagroin sp.
				Nehellenia sp.
			Gomphidae	Ophiogomphus sp.
		Hemiptera (water bugs)	Corixidae	———
			Belostomatidae	Abedus sp.
			Naucoridae	———
		Neuroptera (dobson fly, lacewing, ant lions)	Sialidae	Sialis fuliginosa
	Arachnoidea	Hydracarina (water mites)	Limnocharidae	Limnochares sp.
	Crustacea	Amphipoda (shrimp)	Talitridae	Hyalella azteca
Mollusca	Gastropoda	Pulmonata (snails)	Physidae	Physa sp.
	Pelecypoda (clams)	Sphaeridae	Sphaeridae	Sphaerium sp.
Annelida	Clitellata	Hirudinea (leeches)	Glossiphoniidae	
		Oligochaeta (worms)	Tubificidae	

TABLE IV-8

SUMMARY OF BOTTOM FAUNA COLLECTED AT LITTLE POWDER RIVER SITE NO. 1

				June 12				August 20				October 31			
Class	Order	Family	Genus	No.	% Total No.	Bio-mass (mg)	% Total Bio-mass	No.	% Total No.	Bio mass (mg)	% Total Bio-mass	No.	% Total No.	Bio mass (mg)	% Total Bio-mass
Insecta	Ephemeroptera	Caenidae	Caenis sp.	4	10.0	1.0	13.9	1	2.6	1.0	30.3	4	1.9	0.4	0.6
	Coleoptera	Elmidae	Dubiraphia sp.	2	5.0	0.6	8.3	4	10.3	0.2	6.1	2	1.0	0.1	0.1
	Diptera	Cerotopogonidae	Probezzia sp.	2	5.0	0.4	5.6	0				0			
			Palpomyia sp.	0				2	5.1	0.1	3.0	3	1.4	0.2	0.3
		Chironomidae	Pentaneura sp.	1	2.5	0.2	2.8	0				44	21.0	8.3	11.8
			Chironomus sp.	0				0				5	2.4	2.8	4.0
		Tabanidae	Tabanus sp.	1	2.5	1.3	18.0	0				0			
	Hemiptera	Corixidae		0				1	2.6	0.4	12.1	8	3.8	1.6	2.3
Arachnoidea	Hydracarina	Limnocharidae	Limnochares sp.	1	2.5	0.1	1.4	2	5.1	0.3	9.1	0			
Clitellata	Oligochaeta	Tubificidae		29	72.5	3.6	50.0	29	74.3	1.3	39.4	141	67.5	47.1	67.2
	Hirudinea	Glossiphoniidae		0				0				1	0.5	0.2	0.3
Gastropoda	Pulmonata	Physidae	Physa sp.	0				0				1	0.5	9.4	13.4
			TOTALS	40	100.0%	7.2	100.0%	39	100.0%	3.3	100.0%	209	100.0%	70.1	100.0%

TABLE IV-9

SUMMARY OF BOTTOM FAUNA COLLECTED AT LITTLE POWDER RIVER SITE NO. 2

				June 12				August 20				October 31			
Class	Order	Family	Genus	No.	% Total No.	Bio-mass (mg)	% Total Bio-mass	No.	% Total No.	Bio mass (mg)	% Total Bio-mass	No.	% Total No.	Bio mass (mg)	% Total Bio-mass
Insecta	Ephemeroptera	Caenidae	Caenis sp.	2	11.1	0.6	0.5	3	5.5	0.2	0.8	54	47.4	3.9	11.0
	Coleoptera	Elmidae	Dubiraphia sp.	2	11.1	0.2	0.2	27	49.2	5.8	23.6	2	1.8	0.5	1.4
	Diptera	Ceratopogonidae	Probezzia sp.	4	22.1	0.3	0.3	0				1	0.9	0.1	0.3
			Palpomyia sp.	0				1	1.8	0.1	0.4	1	0.9	0.1	0.3
		Chironomidae	Pentaneura sp.	1	5.6	0.1	0.1	2	3.6	0.1	0.4	37	32.4	5.8	16.4
			Chironomus sp.	0				0				2	1.8	1.3	3.7
	Odonata	Coenagroinidae	Chromagroin sp.	0				2	3.6	0.8	3.2	4	3.5	3.1	8.8
			Amphiagroin sp.	0				1	1.8	0.3	1.2	0			
		Gomphidae	Ophiogomphus sp.	0				1	1.8	0.7	2.8	0			
	Neuroptera	Sialidae	Sialis fuliginosa	0				0				3	2.6	10.7	30.2
Crustacea	Amphipoda	Talitridae	Hyalella azteca	1	5.6	0.2	0.2	1	1.8	0.1	0.4	1	0.9	0.3	0.8
Gastropoda	Pulmonata	Physidae	Physa sp.	2	11.1	6.4	5.4	2	3.6	11.9	48.2	0			
Pelecypoda	Sphaeriacea	Sphaeridae	Sphaerium sp.	3	16.7	110.6	93.0	0				0			
Clitellata	Oligochaeta	Tubificidae		3	16.7	0.35	0.3	12	21.8	4.6	18.6	9	7.8	9.6	27.1
Arachnoidea	Hydracarina	Limnocharidae	Limnochares sp.	0				3	5.5	0.1	0.4	0			
			TOTALS	18	100.0%	118.75	100.0%	55	100.0%	24.7	100.0%	114	100.0%	35.4	100.0%

TABLE IV-10

SUMMARY OF BOTTOM FAUNA COLLECTED AT LITTLE POWDER RIVER STIE NO. 3

Class	Order	Family	Genus	June 12				August 20				November 1			
				No.	% Total No.	Bio-mass (mg)	% Total Bio-mass	No.	% Total No.	Bio mass (mg)	% Total Bio-mass	No.	% Total No.	Bic mass (mg)	% Total Bio-mass
Insecta	Ephemeroptera	Caenidae	Caenis sp	3	7.0	1.3	8.4	24	9.8	2.4	0.6	24	17.4	3.6	6.2
	Coleoptera	Elmidae	Dubiraphia sp.	10	23.3	2.1	13.5	20	8.2	3.6	0.8	1	0.7	0.1	0.2
		Hydrophilidae	Helophorus sp	0				1	0.4	0.5	0.1	0			
		Haliplidae	Brychius sp.	0				0				1	0.7	0.2	0.3
	Diptera	Ceratopogonidae	Probezzia sp.	1	2.3	0.1	0.6	0				1	0.7	0.1	0.2
			Palpomyia sp.	0				10	4.1	4.7	1.1	12	8.7	2.0	3.4
		Chironomidae	Pentaneura sp.	0				10	4.1	1.0	0.2	19	13.9	4.1	7.0
			Chironomus sp.	0				0				1	0.7	0.1	0.2
		Tabanidae	Haematopota sp.	0				1	0.4	5.0	1.2	0			
			Chrysops sp.	0				1	0.4	0.6	0.1	1	0.7	2.6	4.5
	Odonata	Coenagroinidae	Argia sp	1	2.3	0.8	5.2	0				0			
			Chromagroin sp.	0				17	7.0	3.4	0.8	1	0.7	0.1	0.2
			Nehallenia sp.	0				0				1	0.7	1.6	2.8
	Hemiptera	Belostomatidae	Abedus sp.	0				1	0.4	19.4	4.8	0			
		Naucoridae		0				1	0.4	3.7	0.9	0			
Arachnoidea	Hydracarina	Limnocharidae	Limnochares sp.	1	2.3	0.1	0.6	1	0.4	0.5	0.1	0			
Clitellata	Oligochaeta	Tubificidae		27	62.8	11.1	71.7	124	50.8	7.5	1.8	75	54.4	26.8	46.0
Crustacea	Amphipoda	Talitridae	Hyalella azteca	0				3	1.2	2.7	0.7	0			
Gastropoda	Pulmonata	Physidae	Physa sp.	0				28	11.6	127.9	31.6	1	0.7	16.9	29.0
Pelecypoda	Sphaeriacea	Sphaeridae	Sphaerium sp.	0				2	0.8	223.7	55.2	0			
			TOTALS	43	100.0%	15.5	100.0%	244	100.0%	406.6	100.0%	138	100.0%	58.2	100.0%

TABLE IV-11

RELATIVE ABUNDANCE OF BOTTOM FAUNA ON A NUMBERS BASIS
AT THE THREE LITTLE POWDER RIVER STUDY SITES

		Numbers of Organisms per 0.1 m^2								
		Site No. 1			Site No. 2			Site No. 3		
Class	Order	June	August	November	June	August	October	June	August	November
Insecta	Ephemeroptera	2.9	0.7	2.9	0.6	1.1	25.8	0.8	7.4	5.2
	Coleoptera	1.4	2.9	1.4	0.6	9.7	1.0	2.5	6.5	0.4
	Diptera	2.9	1.4	37.4	1.4	1.1	19.6	0.3	6.8	7.3
	Odonata	0	0	0	0	1.4	1.9	0.3	5.2	0.4
	Hemiptera	0	0.7	5.8	0	0	0	0	0.6	0
	Neuroptera	0	0	0	0	0	1.4	0	0	0
Arachnoidea	Hydracarina	0.7	1.4	0	0	1.1	0	0.3	0.3	0
Clitellata	Oligochaeta	20.9	20.9	101.4	0.9	4.3	4.3	6.8	38.2	16.1
	Hirodinea	0	0	0.7	0	0	0	0	0	0
Gastropoda	Pulmonata	0	0	0.7	0.6	0.7	0	0	8.6	0.2
Crustacea	Amphipoda	0	0	0	0.3	0.4	0.5	0	0.9	0
Pelecypoda	Sphaeriacea	0	0	0	0.9	0	0	0	0.6	0
	TOTALS	28.8	28.0	150.3	5.3	19.8	54.5	11.0	75.1	29.6

TABLE IV-12

RELATIVE ABUNDANCE OF BOTTOM FAUNA ON A BIOMASS BASIS
AT THE THREE LITTLE POWDER RIVER STUDY SITES

		Milligrams (mg) per 0.1 m^2								
		Site No. 1			Site No. 2			Site No. 3		
Class	Order	June	August	November	June	August	October	June	August	November
Insecta	Ephemeroptera	0.7	0.7	0.3	0.2	0.1	1.9	0.3	0.7	0.8
	Coleoptera	0.4	0.1	0.1	0.1	2.1	0.2	0.5	1.3	0.1
	Diptera	1.4	0.1	8.1	0.1	0.1	3.5	<0.05	3.5	1.9
	Odonata	0	0	0	0	0.6	1.5	0.2	1.0	0.4
	Hemiptera	0	0.3	1.1	0	0	0	0	7.1	0
	Neuroptera	0	0	0	0	0	5.1	0	0	0
Arachnoidea	Hydracarina	0.1	0.2	0	0	<0.05	0	<0.05	0.2	0
Clitellata	Oligochaeta	2.6	0.9	33.9	0.1	1.6	4.6	2.8	2.3	5.8
	Hirodinea	0	0	0.1	0	0	0	0	0	0
Gastropoda	Pulmonata	0	0	6.8	1.8	4.3	0	0	39.4	3.6
Crustacea	Amphipoda	0	0	0	0.1	<0.05	0.1	0	0.8	0
Pelecypoda	Sphaeriacea	0	0	0	31.8	0	0	0	68.8	0
	TOTALS	5.2	2.3	50.4	34.2	8.8	16.9	3.8	125.1	12.6

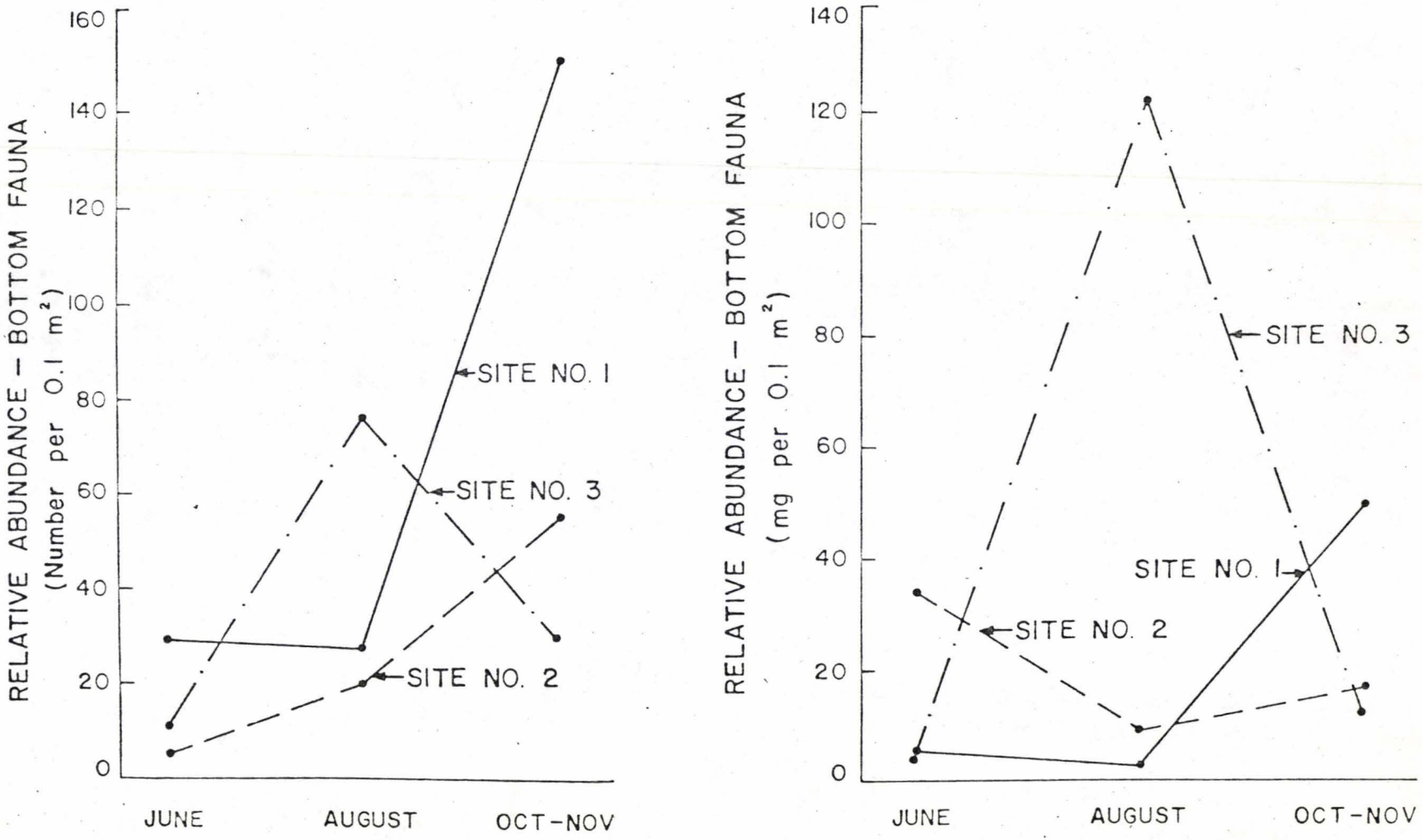

Figure IV-3. Relative Abundance of Bottom Fauna at the Three Little Powder River Study Sites

the investigator has observed that oligocheates may be extremely dense at a certain location, while only a few feet away, sparse numbers are collected. Thus, variation in sampling locations may explain the November increase.

Site No. 2

At Site No. 2, no taxonomic group was found to dominate both numbers and biomass throughout the summer and fall as the oligocheates did at Site No. 1. On a numbers basis, Diptera larvae were the most abundant on June 12 (1.4 per 0.1 m^2); in August, Coleoptera (9.7 per 0.1 m^2); and, on October 31, Ephemeroptera (25.8 per 0.1 m^2) were most numerous (Table IV-11, page IV-28). However, three different taxonomic groups ranked the highest on a biomass basis: pelecypods (freshwater clams) in June (31.8 mg per 0.1 m^2); in August, freshwater snails (4.3 mg per 0.1 m^2); and, in October, Neuroptera larvae, with 5.1 mg per 0.1 m^2 (Table IV-12, page IV-29). Oligocheates were also relatively abundant throughout the sampling period.

On a numbers basis, the general trend in relative abundance at Site No. 2 approximated that at Site No. 1. June and August were quite similar and an increase occurred in late October (Figure IV-3, page IV-30). Mayfly numphs and Diptera larvae accounted for most of this increase. In August, both these groups combined accounted for only 11% of the numbers collected, while in October, 83%. A possible explanation for this would be the hatching of eggs laid by emerging adults during the summer months and the subsequent development of these juvenile forms.

Relative abundance on a biomass basis at Site No. 2 was greatest on June 12 (Figure IV-3, page IV-30). Cause for this was the collection of three freshwater clams which comprised 93% of the biomass (Table IV-9,

page IV-26). Except for this, the general trend in biomass paralleled that found for numbers.

Site No. 3

At each sampling time, oligocheates were the predominant organisms on a numbers basis at Site No. 3, comprising 61.8% of the total number on June 13, 50.9% on August 20 and 54.4% on November 1. Considering biomass, oligocheates were the most abundant during June and November when they represented 73.7% and 46.0%, respectively, of the total collected. On August 20, only small numbers of freshwater clams and snails were collected, but on a biomass basis, they together accounted for 86.5% of the total (Table IV-10, page IV-27). Other taxonomic groups which were relatively common throughout the summer and fall were mayfly nymphs, beetle larvae and adults, Diptera larvae and Odonata nymphs.

General seasonal trends for relative abundance of bottom fauna at Site No. 3 are shown in Figure IV-3, page IV-30. As shown, numbers and biomass followed similar patterns. Lowest densities were found at the June sampling while the greatest concentrations occurred on August 20.

Comparisons Between Community Structure and Overall Trends

The Shannon Species Diversity Index values ($\bar{H}$) on both a numbers and a biomass basis are presented for each study site and each sampling date in Table IV-13. Although differences in community structure were found to exist both between study sites on a given date and between sampling dates for a given site, the results of the Kruskal-Wallis Rank-Sum tests indicate that none of these differences were significant at the .01 level, as shown in Table IV-14.

Table IV-15 summarizes the relative abundance data of the benthic fauna collected at the Little Powder River by sampling time. As the

TABLE IV-13

SHANNON SPECIES DIVERSITY INDEX VALUES ON A NUMBERS AND BIOMASS BASIS FOR BOTTOM FAUNA COLLECTED AT THE THREE LITTLE POWDER RIVER STUDY SITES

	Index Values					
	Site No. 1		Site No. 2		Site No. 3	
	Numbers	Biomass	Numbers	Biomass	Numbers	Biomass
June 1974	0.200	0.239	0.291	0.168	0.137	0.112
August 1974	0.061	0.994	0.351	0.370	0.440	0.399
Oct.-Nov. 1974	0.355	0.341	0.439	0.460	0.403	0.386

TABLE IV-14

RESULTS OF KRUSKAL-WALLIS RANK-SUM TESTS
FOR SHANNON SPECIES DIVERSITY INDEX VALUES

Values below 9.21 = No significant difference
Values above 9.21 = Significant difference

NUMBER BASIS

Between Sampling Dates

Site No. 1	5.42
Site No. 2	0.92
Site No. 3	6.46

Between Sampling Sites

June 12-13, 1974	1.51
August 20, 1974	7.35
Oct. 31-Nov. 1, 1974	1.28

BIOMASS BASIS

Between Sampling Dates

Site No. 1	4.01
Site No. 2	4.18
Site No. 3	7.64

Between Sampling Sites

June 12-13, 1974	1.32
August 20, 1974	5.74
Oct. 31-Nov. 1, 1974	0.80

TABLE IV-15

SUMMARY OF RELATIVE ABUNDANCE DATA FOR THE BOTTOM FAUNA OF THE LITTLE POWDER RIVER

		June				August				Oct.-Nov.				TOTAL			
Class	Order	Mean No.	% Total	Mean Biomass (mg)	% Total	Mean No.	% Total	Mean Biomass (mg)	% Total	Mean No.	% Total	Mean Biomass (mg)	% Total	No.	% Total	Biomass (mg)	% Total
Insecta	Ephemeroptera	1.4	9.4	0.4	2.8	3.1	7.6	0.5	1.1	11.3	14.5	1.0	3.8	15.8	11.8	1.9	2.2
	Coleoptera	1.5	10.1	0.3	2.1	6.4	15.6	1.7	3.7	0.9	1.2	0.1	0.4	8.8	6.6	2.1	2.4
	Diptera	1.5	10.1	0.5	3.5	3.1	7.6	1.2	2.6	21.4	27.3	4.5	16.9	26.0	19.4	6.2	7.1
	Odonata	0.1	0.7	0.1	0.7	2.2	5.4	0.5	1.1	0.8	1.0	0.6	2.3	3.1	2.3	1.2	1.4
	Hemiptera	0	0	0	0	0.4	1.0	2.5	5.4	1.9	2.4	0.4	1.5	2.3	1.7	2.9	3.3
	Neuroptera	0	0	0	0	0	0	0	0	0.5	0.6	1.7	6.4	0.5	0.4	1.7	2.0
Arachnoidea	Hydracarina	0.3	2.0	<0.05		0.9	2.2	0.1	0.2	0	0	0	0	1.2	0.9	0.1	0.1
Clitellata	Oligochaeta	9.5	63.7	1.8	12.6	21.1	51.5	1.6	3.5	40.6	52.0	14.8	55.5	71.2	53.2	18.2	21.0
	Hirodinea	0	0	0	0	0	0	0	0	0.2	0.3	<0.05		0.2	0.1	0.05	
Gastropoda	Pulmonata	0.2	1.3	0.6	4.2	3.1	7.6	14.6	31.8	0.3	0.4	3.5	13.2	3.6	2.7	18.7	21.6
Crustacea	Amphipoda	0.1	0.7	<0.05		0.4	1.0	0.3	0.7	0.2	0.3	<0.05		0.7	0.5	0.3	0.3
Pelecypoda	Sphaeriacea	0.3	2.0	10.6	74.1	0.2	0.5	22.9	49.9	0	0	0	0	0.5	0.4	33.5	38.6
	TOTAL	14.9	100.0%	14.3	100.0%	40.9	100.0%	45.9	100.0%	78.1	100.0%	26.6	100.0%	133.9	100.0%	86.8	100.0%

summer progressed, there was an upward trend in relative density on a numbers basis. Possible explanations for this could be the decrease in the feeding activities of the fish present, and the hatching and development of juvenile intertebrate forms. Also, variation in sampling locations is a possibility. Considering biomass, the peak concentrantion occurred at the August sampling. The chief cause for this was the collection of several freshwater clams and snails which comprised only 8.1% of the August numbers, but 81.7% of the biomass on that date.

Overall, lumping data from the study sites and the sampling times, oligocheates were the most common form present on a numbers basis, (53.3%) while Diptera larvae ranked second (26.0%) and mayfly nymphs third (15.8%). All other orders comprised less than 10% of the total. In regard to biomass, freshwater clams accounted for 38.6% of the total. Freshwater snails ranked second (21.6%) while oligocheates were third (21.0%). No other group comprised more than 10% of the total biomass.

Water Quality

Water quality results are reported on the attached data sheets for each of the three (3) sample sites and each of the three (3) sample dates as listed below:

Site #1 (south) 6-12-74: pages IV-41 and IV-42

Site #2 (middle) 6-12-74: pages IV-43 and IV-44

Site #3 (north) 6-12-74: pages IV-45 and IV-46

Site #1 (south) 8-20-74: pages IV-47 and IV-48

Site #2 (middle) 8-20-74: pages IV-49 and IV-50

Site #3 (north) 8-20-74: pages IV-51 and IV-52

Site #1 (south) 10-31-74: pages IV-53 and IV-54

Site #2 (middle) 10-31-74: pages IV-55 and IV-56

Site #3 (north) 10-31-74: pages IV-57 and IV-58

This data is summarized in Tables IV-16 and IV-17. Table IV-17 is presented as a listing of the maximum and minimum values as compared with the expected ranges of values for each constituent. Since this is an assessment study of the water quality within the Little Powder River, additional water quality sampling will be needed to expand this table to represent at least one full year of data.

TABLE IV-16

LITTLE POWDER RIVER WATER QUALITY DATA

Water Quality Parameter/Unit		Date 6-12-74			8-20-74			10-31-74		
		Site No. 1	Site No. 2	Site No. 3	Site No. 1	Site No. 2	Site No. 3	Site No. 1	Site No. 2	Site No. 3
Calcium	mg/l	110	85	93	78	46	83	12	17	16
Magnesium	mg/l	149	106	116	56	42	42	18	19	25
Sodium	mg/l	690	650	610	190	143	197	53	57	64
Potassium	mg/l	9	9	9	10	8	8	7	7	7
Carbonate	mg/l	0	0	0	0	0	0	0	0	0
Bicarbonate	mg/l	606	586	583	259	192	326	66	73	85
Sulfate	mg/l	1836	1555	1549	606	427	555	155	178	202
Chloride	mg/l	9	11	13	7	11	6	13	11	10
Nitrate	mg/l	1.7	2.4	2.4	1.8	1.8	1.3	0.6	0.5	0.8
Fluoride	mg/l	0.5	0.9	0.9	0.5	0.5	0.6	0.1	0.2	0.2
Conductance	MHOS	3685	3484	3457	1493	1052	1487	400	274	130
COD	mg/l	29	24	25	59	46	44	27	30	29
pH	Unit	8.1	8.2	8.1	7.3	7.6	7.9	7.0	6.8	6.6
Turbidity	JTU	115	178	155	133	181	52	1500	1500	1400
Hardness	mg/l	886	651	711	425	289	380	105	121	145
Alkalinity	mg/l	298	288	286	127	94	160	32	36	42
Ammonia	mg/l	0	0	0	0	0	0	18	8	8
Organic N	mg/l	2	2	1	2	2	2	47	47	37
Nitrate-N trite	mg/l	1.7	2.4	2.4	1.8	1.8	1.3	0.6	0.5	0.8
Phosphorus	mg/l	0	0	0	0.05	0.04	0.03	0.04	0.02	0.03
Suspended Solids	mg/l	38	2365	1526	105	104	114	25,800	38,300	34,000
ROE	mg/l	3126	2706	2700	1078	748	1052	370	380	400
Total Solids	mg/l	3164	5071	4226	1183	852	1166	26,170	38,680	34,400

TABLE IV-1 ontinued

Water Quality Parameter	unit	Date 6-12-74 Site No. 1	Site No. 2	Site No. 3	8-20-74 Site No. 1	Site No. 2	Site No. 3	10-31-74 Site No. 1	Site No. 2	Site No. 3
Arsenic	mg/1	0.009	0.009	0.01	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Barium	mg/1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	mg/1	0.3	0.4	0.3	0.12	0.08	0.11	0.01	0.02	0.02
Cadmium	mg/1	<0.001	<0.001	<0.001	<0.009	<0.005	<0.007	<0.001	<0.004	<0.001
Copper	mg/1	<0.01	<0.01	<0.01	0.07	0.06	0.07	<0.01	<0.01	<0.01
Chromium (hex)	mg/1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride	mg/1	0.5	0.9	0.9	0.5	0.5	0.6	0.1	0.2	0.2
Iron (total)	mg/1	1.3	2.3	1.8	0.44	3.4	9	10	11	19
Lead	mg/1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	mg/1	0.1	0.1	0.4	<0.05	<0.05	<0.05	<0.05	0.17	<0.05
Mercury	mg/1	<0.001	0.025	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium					0.001	0.002	0.002	0.002	0.002	0.002
Silver	mg/1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Zinc	mg/1	0.07	0.07	0.01	0.26	0.10	0.15	0.09	0.6	0.03
Cyanide	mg/1	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
MBAS	mg/1	<0.01	<0.01	0.007	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenol	mg/1	0.005	<0.005	0.01	0.004	0.007	0.003	<0.02	<0.001	0.02
Oil and Grease	mg/1	0	0	1.2	2.1	2.0	2.1	2.5	3.3	2.9
Sulfides	mg/1					0	0.7	0	0.9	0
Field										
Flow	cfs					0.27		2.4		
pH	Unit	7.6	2.4		8.0	8.6	8.0	7.8		
Conductance	MHOS	1050	3250	3315	1350	1300	1380	950		
DO	mg/1	6.9	7.45	7.45	9.0	9.1	9.3	9.0		
Temp.	°C	17	23.5	21	20	22	18	16		

TABLE IV-17

TABLE OF MAXIMUM, MINIMUM, AND EXPECTED AVERAGE VALUES FOR WATER QUALITY PARAMETERS REPORTED BY THREE (3) SAMPLING PERIODS AS LISTED IN TABLE IV-16
(Data for samples taken between May and October 1974)

Parameter		Max	Min	Expected Range
Calcium	mg/1	110	12	20-80
Magnesium	mg/1	149	18	40-90
Sodium	mg/1	690	53	200-500
Potassium	mg/1	10	7	6-12
Carbonate	mg/1	0	0	0
Bicarbonate	mg/1	606	66	300-600
Sulfate	mg/1	1836	155	600-1200
Chloride	mg/1	13	6	8-10
Nitrate	mg/1	2.4	0.5	1.5-2.0
Fluoride	mg/1	0.9	0.1	0.6-0.9
Conductance	μMHOS	3685	130	1000-2500
COD	mg/1	59	24	30-50
pH	units	8.2	6.6	6.0-8.0
Turbidity	JTU	178	52	90-130
Hardness	mg/1	886	105	550-750
Alkalinity	mg/1	298	32	150-250
Ammonia	mg/1	18	8	0-20
Organic N	mg/1	47	1	0-2
Nitrite-Nitrate	mg/1	2.4	0.5	1.2-2.0
Phosphorus	mg/1	0.05	0	0-0.03
Suspended Solids	mg/1	38,300	38	100-5000
Total Solids	mg/1	38,680	852	1000-8000
Arsenic	mg/1	0.01	<0.007	<0.007
Barium	mg/1	0	0	<0.5
Boron	mg/1	0.12	0.01	0.01-0.1
Cadmium	mg/1	0.009	<0.001	<0.001
Copper	mg/1	0.07	<0.01	<0.01
Chromium	mg/1	0	0	<0.01
Iron (total)	mg/1	19	0.44	1.0-5.0
Iron (Diss.)	mg/1	8	0.17	1.0-3.0
Lead	mg/1	0	0	<0.01
Manganese	mg/1	0.4	<0.05	0.1-0.3
Mercury	mg/1	0.025	<0.001	<0.001
Nickel	mg/1	0	0	<0.1
Silver	mg/1	0	0	<0.05
Zinc	mg/1	0.6	0.01	0.01-0.3
Cyanide	mg/1	0	0	<0.008
Phenol	mg/1	0.02	0.007	<0.01
Oil and Grease	mg/1	3.3	1.2	1-3

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 1 of 2)

Time Collected _____ Collector _____

Date Collected 6-12-74 Facility Name _____

Stream Name(s)
Little Powder River

Source of Sample: (Exact Location)
Site #1 - South

Physical Observations, Remarks: | Weather Cond. _____

Temp.(air) _____ °
Ground Cond.

Flow	Field Dissolved Oxygen	Field pH	Field Temp.

CATIONS	meq/1	mg/1	(Base)	ANIONS	meq/1	mg/1	(Base)
Calcium (Ca)	5.48	110		Carbonate (CO_3)	0.00	0.0	
Magnesium (Mg)	12.22	149		Bicarbonate (HCO_3)	9.93	606	
Sodium (Na)	30.01	690		Sulfate (SO_4)	38.23	1836	
Potassium (K)	0.23	9.1		Chloride (Cl)	0.25	9.0	
				Nitrate (NO_3)	0.03	1.7	
				*Phosphate (PO_4) as (P)	0.00	0.01	
				Fluoride (F)	0.03	0.5	
Total Cations	47.49			Total Anions	48.47		

Values reported are mg/1 unless otherwise stated.

*Not included in Total Anions

This Test	Base Level		
3685	( )		Conductance (μmhos)
29	( )		COD
8.1	( )		pH
115	( )		Turbidity (JTU)
886	( )		Hardness
298	( )		Alkalinity
	( )		Total Acidity
	( )		Free Acidity
	( )		
	( )		

This Test	Base Level		
0.0	( )		Ammonia (N)
1.5	( )		Organic Nitrogen (N)
1.7	( )		Nitrate + Nitrite (N)
0.0	( )		Total Phosphorus (P)
38	( )		Susp. Solids → 3164 Total
9.4	( )		Vol.Susp.Solids
3126	( )		ROE

FOR LAB USE ONLY

Lab Number: _____ Rec'd by: _____

Date sample rec'd: _____ Time: _____

Date analysis completed: _____

Date results forwarded: _____

Total tests requested: _____ Tests run: _____

Lab Section: _____ Supervisor: _____

Transported by: _____

Received by: _____

Transported by: _____

Received by: _____

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 2 of 2)

Time Collected: _____

Date Collected: 6-12-74

Stream Name(s): Little Powder River

Source of Sample: South Site #1

Special sampling and testing procedures are required for these water tests. Indicate on form if preservative has been added to sample and time tests were completed.

(Values reported are mg/l unless otherwise stated.)

Preservative & Time	This Test	Base Level		Preservative & Time	This Test	Base Level	
	0.009	( )	Arsenic		<0.01	( )	Lead
	<0.5	( )	Barium		0.1	( )	Manganese
	0.3	( )	Boron		<0.001	( )	Mercury
	<0.001	( )	Cadmium		<0.1	( )	Nickel
	0.01	( )	Copper			( )	Selenium
		( )	Chromium (tri)		<0.05	( )	Silver
	<0.01	( )	Chromium (hex)		0.07	( )	Zinc
	0.5	( )	Fluoride		<0.008	( )	Cyanide
	1.3	( )	Iron (Total)		<0.010	( )	MBAS
	0.5	( )	Iron (Dissolved)		0.005	( )	Phenol (ppm)
			BOD		0.0	( )	Oil & Grease
			Fecal Coliforms/ 100 ml			( )	Sulfides

SPECIAL INSTRUCTIONS

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 1 of 2)

Time Collected _____ Collector _____

Date Collected 6-12-74 Facility Name _____

Stream Name(s)
Little Powder River

Source of Sample: (Exact Location)
Site #2 - Middle

Physical Observations, Remarks:	Weather Cond.
	Temp.(air) °F
	Ground Cond.

Flow	Field Dissolved Oxygen	Field pH	Field Temp.

CATIONS	meq/l	mg/l	(Base)	ANIONS	meq/l	mg/l	(Base)
Calcium (Ca)	4.24	85		Carbonate (CO_3)	0.00	0.0	
Magnesium (Mg)	8.76	106		Bicarbonate (HCO_3)	9.60	586	
Sodium (Na)	28.27	650		Sulfate (SO_4)	32.37	1555	
Potassium (K)	0.23	8.8		Chloride (Cl)	0.31	11.0	
				Nitrate (NO_3)	0.04	2.4	
				*Phosphate (PO_4)as(P)	0.00	0.0	
				Fluoride (F)	0.05	0.9	
Total Cations	41.50			Total Anions	42.37		

Values reported are mg/l unless otherwise stated.

*Not included in Total Anions

This Test	Base Level		This Test	Base Level	
3484	( )	Conductance (μmhos)	0.0	( )	Ammonia (N)
24	( )	COD	1.5	( )	Organic Nitrogen (N)
8.2	( )	pH	2.4	( )	Nitrate + Nitrite (N)
178	( )	Turbidity (JTU)	0.0	( )	Total Phosphorus (P)
651	( )	Hardness	2365	( )	Susp. Solids → 5071 Total
288	( )	Alkalinity	177	( )	Vol.Susp.Solids
	( )	Total Acidity	2706	( )	ROE
	( )	Free Acidity			
	( )				
	( )				

FOR LAB USE ONLY

Lab Number: _____ Rec'd by: _____

Date sample rec'd: _____ Time: _____

Date analysis completed: _____

Date results forwarded: _____

Total tests requested: _____ Tests run: _____

Lab Section: _____ Supervisor: _____

Transported by: _____

Received by: _____

Transported by: _____

Received by: _____

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 2 of 2)

Time Collected: _____

Date Collected: 6-12-74

Stream Name(s): Little Powder River

Source of Sample: Middle Site #2

Special sampling and testing procedures are required for these water tests. Indicate on form if preservative has been added to sample and time tests were completed.

(Values reported are mg/l unless otherwise stated.)

Preservative & Time	This Test	Base Level		Preservative & Time	This Test	Base Level	
	0.009	( )	Arsenic		<0.01	( )	Lead
	<0.5	( )	Barium		0.1	( )	Manganese
	0.4	( )	Boron		0.025	( )	Mercury
	<0.001	( )	Cadmium		<0.1	( )	Nickel
	<0.01	( )	Copper			( )	Selenium
		( )	Chromium (tri)		<0.05	( )	Silver
	<0.01	( )	Chromium (hex)		0.7	( )	Zinc
	0.9	( )	Fluoride		<0.008	( )	Cyanide
	2.3	( )	Iron (Total)		<0.01	( )	MBAS
	0.7	( )	Iron (Dissolved)		<0.005	( )	Phenol (ppm)
			BOD		0.0	( )	Oil & Grease
			Fecal Coliforms/ 100 ml			( )	Sulfides

SPECIAL INSTRUCTIONS

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 1 of 2)

Time Collected _____ Collector _____

e Collected 6-12-74 Facility Name _____

Stream Name(s)
Little Powder River

Source of Sample: (Exact Location)
Site #3 - North

Physical Observations, Remarks: | Weather Cond. _____

Temp.(air) _____ °
Ground Cond.

Flow	Field Dissolved Oxygen	Field pH	Field Temp.

CATIONS	meq/l	mg/l	(Base)	ANIONS	meq/l	mg/l	(Base
Calcium (Ca)	4.64	93		Carbonate (CO_3)	0.00	0.0	
Magnesium (Mg)	9.56	116		Bicarbonate (HCO_3)	9.55	583	
Sodium (Na)	26.53	610		Sulfate (SO_4)	32.25	1549	
Potassium (K)	0.23	9.1		Chloride (Cl)	0.36	13.0	
				Nitrate (NO_3)	0.04	2.4	
				*Phosphate (PO_4)as(P)	0.00	0.0	
				Fluoride (F)	0.05	0.9	
Total Cations	40.96			Total Anions	42.25		

Values reported are mg/l unless otherwise stated.

*Not included in Total Anions

This Test	Base Level		This Test	Base Level	
3457	( )	Conductance (μMHOS)	0.0	( )	Ammonia (N)
25	( )	COD	1.1	( )	Organic Nitrogen (N)
8.1	( )	pH	2.4	( )	Nitrate + Nitrite (N)
155	( )	Turbidity (JTU)	0.0	( )	Total Phosphorus (P)
711	( )	Hardness	1526	( )	Susp. Solids ← 4226 Total
286	( )	Alkalinity	131	( )	Vol.Susp.Solids
	( )	Total Acidity	2700	( )	ROE
	( )	Free Acidity			
	( )				
	( )				

FOR LAB USE ONLY

Lab Number: _____ Rec'd by: _____

Date sample rec'd: _____ Time: _____

Date analysis completed: _____

Date results forwarded: _____

Total tests requested: _____ Tests run: _____

Lab Section: _____ Supervisor: _____

Transported by: _____

Received by: _____

Transported by: _____

Received by: _____

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 2 of 2)

Time Collected: _____

Date Collected: 6-12-74

Stream Name(s): Little Powder River

Source of Sample: North Site #3

Special sampling and testing procedures are required for these water tests. Indicate on form if preservative has been added to sample and time tests were completed.

(Values reported are mg/l unless otherwise stated.)

Preservative & Time	This Test	Base Level		Preservative & Time	This Test	Base Level	
	0.01	( )	Arsenic		<0.01	( )	Lead
	<0.5	( )	Barium		0.4	( )	Manganese
	0.3	( )	Boron		0.002	( )	Mercury
	<0.001	( )	Cadmium		<0.1	( )	Nickel
	<0.01	( )	Copper			( )	Selenium
		( )	Chromium (tri)		<0.05	( )	Silver
	<0.01	( )	Chromium (hex)		0.01	( )	Zinc
	0.9	( )	Fluoride		<0.008	( )	Cyanide
	1.8	( )	Iron (Total)		0.007	( )	MBAS
	0.7	( )	Iron (Dissolved)		0.01	( )	Phenol (ppm)
			BOD		1.2	( )	Oil & Grease
			Fecal Coliforms/ 100 ml			( )	Sulfides

SPECIAL INSTRUCTIONS

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 1 of 2)

Time Collected _____ Collector _____

Date Collected 8-20-74 Facility Name _____

Stream Name(s)

Little Powder River

Source of Sample: (Exact Location)
South Site (#1) South

Physical Observations, Remarks:

Weather Cond. _____

Temp.(air) _____ °

Ground Cond.

Flow	S.	Conduc.	Field Dissolved Oxygen	Field pH	Field Temp.
.47cfs	1°/00	1350	9.0	8.0	20°C

CATIONS	meq/l	mg/l	(Base)	ANIONS	meq/l	mg/l	(Base)
Calcium (Ca)	3.91	78		Carbonate (CO_3)	0.00	0.0	
Magnesium (Mg)	4.59	56		Bicarbonate (HCO_3)	4.25	259	
Sodium (Na)	8.26	190		Sulfate (SO_4)	12.61	606	
Potassium (K)	0.25	9.8		Chloride (Cl)	0.21	7.3	
				Nitrate (NO_3)	0.03	1.8	
				*Phosphate (PO_4)as(P)	0.00	0.06	
				Fluoride (F)	0.02	0.5	
Total Cations	17.01			Total Anions	17.69		

Values reported are mg/l unless otherwise stated.

*Not included in Total Anions

This Test	Base Level		This Test	Base Level	
1493	( )	Conductance (µmhos)	0.00	( )	Ammonia (N)
58.58	( )	COD	1.96	( )	Organic Nitrogen (N)
7.3	( )	pH	1.80	( )	Nitrate + Nitrite (N)
133	( )	Turbidity (JTU)	0.05	( )	Total Phosphorus (P)
425	( )	Hardness	105	( )	Susp. Solids → 1183 Total
127	( )	Alkalinity	9.9	( )	Vol.Susp.Solids
	( )	Total Acidity	1078	( )	ROE
	( )	Free Acidity			
	( )				
	( )				

FOR LAB USE ONLY

Lab Number: _____ Rec'd by: _____

Date sample rec'd: _____ Time: _____

Date analysis completed: _____

Date results forwarded: _____

Total tests requested: _____ Tests run: _____

Lab Section: _____ Supervisor: _____

Transported by: _____

Received by: _____

Transported by: _____

Received by: _____

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 2 of 2)

Time Collected: _____

Date Collected: 8-20-74

Stream Name(s): Little Powder River

Source of Sample: South Site (#1) South

Special sampling and testing procedures are required for these water tests. Indicate on form if preservative has been added to sample and time tests were completed.

(Values reported are mg/l unless otherwise stated.)

Preservative & Time	This Test	Base Level		Preservative & Time	This Test	Base Level	
	<0.007	( )	Arsenic		<0.01	( )	Lead
	<0.5	( )	Barium		<0.05	( )	Manganese
	0.124	( )	Boron		<0.001	( )	Mercury
	0.009	( )	Cadmium		<0.1	( )	Nickel
	0.07	( )	Copper		0.001	( )	Selenium
		( )	Chromium (tri)		<0.05	( )	Silver
	<0.01	( )	Chromium (hex)		0.26	( )	Zinc
	0.50	( )	Fluoride		<0.008	( )	Cyanide
	0.44	( )	Iron (Total)		<0.01	( )	MBAS
	0.17	( )	Iron (Dissolved)		0.004	( )	Phenol (ppm)
	6.00	(Not valid)	BOD		2.1	( )	Oil & Grease
			Fecal Coliforms/ 100 ml		1.1	( )	Sulfides

SPECIAL INSTRUCTIONS

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 1 of 2)

Time Collected _____ Collector _____

Date Collected 8-20-74 Facility Name _____

Stream Name(s)
Little Powder River

Source of Sample: (Exact Location)
Middle Site (#2)

Physical Observations, Remarks: | Weather Cond. _____

Temp.(air) _____ °
Ground Cond.

Flow S.C.	S.	Field Dissolved Oxygen	Field pH	Field Temp.
1000	.8°/00	9.1	8.6	22°C

CATIONS	meq/l	mg/l	(Base)	ANIONS	meq/l	mg/l	(Base)
Calcium (Ca)	2.32	46		Carbonate (CO_3)	0.00	0.0	
Magnesium (Mg)	3.46	42		Bicarbonate (HCO_3)	3.15	192	
Sodium (Na)	6.22	143		Sulfate (SO_4)	8.89	427	
Potassium (K)	0.20	7.7		Chloride (Cl)	0.31	11	
				Nitrate (NO_3)	0.03	1.8	
				*Phosphate (PO_4)as(P)	0.00	0.05	
				Fluoride (F)	0.03	0.5	
Total Cations	12.20			Total Anions	12.41		

Values reported are mg/l unless otherwise stated.

*Not included in Total Anions

This Test	Base Level		This Test	Base Level	
1052	( )	Conductance (µmhos)	0.00	( )	Ammonia (N)
46.46	( )	COD	1.60	( )	Organic Nitrogen (N)
7.6	( )	pH	1.80	( )	Nitrate + Nitrite (N)
181	( )	Turbidity (JTU)	0.04	( )	Total Phosphorus (P)
289	( )	Hardness	104	( )	Susp. Solids → 852 Total
94	( )	Alkalinity	11	( )	Vol.Susp.Solids
	( )	Total Acidity	748	( )	ROE
	( )	Free Acidity			
	( )				
	( )				

FOR LAB USE ONLY

Lab Number: _____ Rec'd by: _____

Date sample rec'd: _____ Time: _____

Date analysis completed: _____

Date results forwarded: _____

Total tests requested: _____ Tests run: _____

Lab Section: _____ Supervisor: _____

Transported by: _____

Received by: _____

Transported by: _____

Received by: _____

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 2 of 2)

Time Collected: _____

Date Collected: 8-20-74

Stream Name(s): Little Powder River

Source of Sample: Middle Site (#2)

Special sampling and testing procedures are required for these water tests. Indicate on form if preservative has been added to sample and time tests were completed.

(Values reported are mg/l unless otherwise stated.)

Preservative & Time	This Test	Base Level		Preservative & Time	This Test	Base Level	
	<0.007	( )	Arsenic		<0.01	( )	Lead
	<0.5	( )	Barium		<0.05	( )	Manganese
	0.078	( )	Boron		<0.001	( )	Mercury
	0.005	( )	Cadmium		<0.1	( )	Nickel
	0.06	( )	Copper		0.002	( )	Selenium
		( )	Chromium (tri)		<0.05	( )	Silver
	<0.01	( )	Chromium (hex)		0.10	( )	Zinc
	0.5	( )	Fluoride		<0.008	( )	Cyanide
	3.36	( )	Iron (Total)		<0.01	( )	MBAS
	1.05	( )	Iron (Dissolved)		0.007	( )	Phenol (ppm)
	21.00	(not valid)	BOD		2.00	( )	Oil & Grease
			Fecal Coliforms/ 100 ml		0.00	( )	Sulfides

SPECIAL INSTRUCTIONS

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 1 of 2)

Time Collected _____ Collector _____

Date Collected 8-20-74 Facility Name _____

Stream Name(s)
Little Powder River

Source of Sample: (Exact Location)
North Site (#3)

Physical Observations, Remarks:

Weather Cond. _____

Temp.(air) _____ °

Ground Cond.

Flow	S.C.	S.	Field Dissolved Oxygen	Field pH	Field Temp.
1380	1°/00		9.3	8.0	18°C

CATIONS	meq/1	mg/1	(Base)	ANIONS	meq/1	mg/1	(Base
Calcium (Ca)	4.12	83		Carbonate (CO_3)	0.00	0.0	
Magnesium (Mg)	3.47	42		Bicarbonate (HCO_3)	5.35	326	
Sodium (Na)	8.57	197		Sulfate (SO_4)	11.55	555	
Potassium (K)	0.22	8.6		Chloride (Cl)	0.17	5.8	
				Nitrate (NO_3)	0.02	1.3	
				*Phosphate (PO_4)as(P)	0.00	0.04	
				Fluoride (F)	0.03	0.6	
Total Cations	13.03			Total Anions	12.4		

Values reported are mg/1 unless otherwise stated.

*Not included in Total Anions

This Test	Base Level		
1487	( )	Conductance (μmhos)	
44.44	( )	COD	
7.9	( )	pH	
52	( )	Turbidity (JTU)	
380	( )	Hardness	
160	( )	Alkalinity	
	( )	Total Acidity	
	( )	Free Acidity	
	( )		
	( )		

This Test	Base Level		
0.00	( )	Ammonia (N)	
1.78	( )	Organic Nitrogen (N)	
1.30	( )	Nitrate + Nitrite (N)	
0.03	( )	Total Phosphorus (P)	
114	( )	Susp. Solids	1166 Total
9.1	( )	Vol.Susp.Solids	
1052	( )	ROE	

FOR LAB USE ONLY

Lab Number: _____ Rec'd by: _____

Date sample rec'd: _____ Time: _____

Date analysis completed: _____

Date results forwarded: _____

Total tests requested: _____ Tests run: _____

Lab Section: _____ Supervisor: _____

Transported by: _____

Received by: _____

Transported by: _____

Received by: _____

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 2 of 2)

Time Collected: _____

Date Collected: 8-20-74

Stream Name(s): Little Powder River

Source of Sample: North Site (#3)

Special sampling and testing procedures are required for these water tests. Indicate on form if preservative has been added to sample and time tests were completed.

(Values reported are mg/l unless otherwise stated.)

Preservative & Time	This Test	Base Level		Preservative & Time	This Test	Base Level	
	<0.07	( )	Arsenic		<0.01	( )	Lead
	<0.5	( )	Barium		<0.05	( )	Manganese
	0.11	( )	Boron		<0.001	( )	Mercury
	0.007	( )	Cadmium		<0.1	( )	Nickel
	0.07	( )	Copper		0.002	( )	Selenium
		( )	Chromium (tri)		<0.05	( )	Silver
	<0.01	( )	Chromium (hex)		0.15	( )	Zinc
	0.6	( )	Fluoride		<0.008	( )	Cyanide
	9.2	( )	Iron (Total)		<0.01	( )	MBAS
	7.4	( )	Iron (Dissolved)		0.003	( )	Phenol (ppm)
	50.00	(not valid)	BOD		2.10	( )	Oil & Grease
			Fecal Coliforms/ 100 ml		0.66	( )	Sulfides

SPECIAL INSTRUCTIONS

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 1 of 2)

Time Collected _____ Collector _____

Date Collected 10-31-74 Facility Name _____

Stream Name(s)
Little Powder River

Source of Sample: (Exact Location)
South Site #1

Physical Observations, Remarks:	Weather Cond.
	Temp.(air) °F
	Ground Cond.

Flow	Field Dissolved Oxygen	Field pH	Field Temp.
1.55cfs			

CATIONS	meq/l	mg/l	(Base)	ANIONS	meq/l	mg/l	(Base)
Calcium (Ca)	0.62	12		Carbonate (CO_3)	0.00	0.0	
Magnesium (Mg)	1.47	18		Bicarbonate (HCO_3)	1.08	66	
Sodium (Na)	2.31	53		Sulfate (SO_4)	3.22	155	
Potassium (K)	0.18	7.2		Chloride (Cl)	0.36	13	
				Nitrate (NO_3)	0.01	0.6	
				*Phosphate (PO_4)as(P)	0.001	0.023	
				Fluoride (F)	0.01	0.1	
Total Cations	4.58			Total Anions	4.68		

Values reported are mg/l unless otherwise stated.

*Not included in Total Anions

This Test	Base Level		This Test	Base Level	
400	( )	Conductance (μmhos)	17.6	( )	Ammonia (N)
27.2	( )	COD	46.9	( )	Organic Nitrogen (N)
7.0	( )	pH	0.6	( )	Nitrate + Nitrite (N)
1500	( )	Turbidity (JTU)	0.035	( )	Total Phosphorus (P)
105	( )	Hardness	25,800	( )	Susp. Solids → 26,168 Total
32	( )	Alkalinity	23,500	( )	Vol.Susp.Solids
	( )	Total Acidity	368	( )	ROE
	( )	Free Acidity			
	( )				
	( )				

FOR LAB USE ONLY

Lab Number: _____ Rec'd by: _____

Date sample rec'd: _____ Time: _____

Date analysis completed: _____

Date results forwarded: _____

Total tests requested: _____ Tests run: _____

Lab Section: _____ Supervisor: _____

Transported by: _____

Received by: _____

Transported by: _____

Received by: _____

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 2 of 2)

Time Collected: _____

Date Collected: 10-31-74

Stream Name(s): Little Powder River

Source of Sample: South Site #1

Special sampling and testing procedures are required for these water tests. Indicate on form if preservative has been added to sample and time tests were completed.

(Values reported are mg/l unless otherwise stated.)

Preservative & Time	This Test	Base Level		Preservative & Time	This Test	Base Level	
	<0.007	( )	Arsenic		<0.01	( )	Lead
	<0.5	( )	Barium		<0.05	( )	Manganese
	0.01	( )	Boron		<0.001	( )	Mercury
	<0.001	( )	Cadmium		<0.1	( )	Nickel
	<0.01	( )	Copper		0.002	( )	Selenium
		( )	Chromium (tri)		<0.05	( )	Silver
	<0.01	( )	Chromium (hex)		0.09	( )	Zinc
	0.1	( )	Fluoride		<0.008	( )	Cyanide
	10	( )	Iron (Total)		<0.01	( )	MBAS
	3.3	( )	Iron (Dissolved)		<0.02	( )	Phenol (ppm)
			BOD		2.5	( )	Oil & Grease
			Fecal Coliforms/ 100 ml		0.0	( )	Sulfides

SPECIAL INSTRUCTIONS

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 1 of 2)

Time Collected _____ Collector _____

e Collected 10-31-74 Facility Name _____

Stream Name(s)
Little Powder River

Source of Sample: (Exact Location)
Niddle Site #2

Physical Observations, Remarks: | Weather Cond. _____

Temp.(air) _____ °
Ground Cond.

Flow	Field Dissolved Oxygen	Field pH	Field Temp.

CATIONS	meq/l	mg/l	(Base)	ANIONS	meq/l	mg/l	(Base
Calcium (Ca)	0.85	17		Carbonate (CO_3)	0.00	0.0	
Magnesium (Mg)	1.58	19		Bicarbonate (HCO_3)	1.20	73	
Sodium (Na)	2.48	57		Sulfate (SO_4)	3.70	178	
Potassium (K)	0.19	7.4		Chloride (Cl)	0.31	11	
				Nitrate (NO_3)	0.01	0.5	
				*Phosphate (PO_4)as(P)	0.000	0.010	
				Fluoride (F)	0.01	0.2	
Total Cations	5.10			Total Anions	5.23		

Values reported are mg/l unless otherwise stated.

*Not included in Total Anions

This Test	Base Level		This Test	Base Level	
274	( )	Conductance (μmhos)	7.8	( )	Ammonia (N)
30.2	( )	COD	46.9	( )	Organic Nitrogen (N)
6.8	( )	pH	0.5	( )	Nitrate + Nitrite (N)
1500	( )	Turbidity (JTU)	0.018	( )	Total Phosphorus (P)
121	( )	Hardness	38,300	( )	Susp. Solids ← 38.676 Total
36	( )	Alkalinity	35,300	( )	Vol.Susp.Solids
	( )	Total Acidity	376	( )	ROE
	( )	Free Acidity			
	( )				
	( )				

FOR LAB USE ONLY

Lab Number: _____ Rec'd by: _____

Date sample rec'd: _____ Time: _____

Date analysis completed: _____

Date results forwarded: _____

Total tests requested: _____ Tests run: _____

Lab Section: _____ Supervisor: _____

Transported by: _____

Received by: _____

Transported by: _____

Received by: _____

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 2 of 2)

Time Collected: _____

Date Collected: 10-31-74

Stream Name(s): Little Powder River

Source of Sample: Middle Site #2

Special sampling and testing procedures are required for these water tests. Indicate on form if preservative has been added to sample and time tests were completed.

(Values reported are mg/l unless otherwise stated.)

Preservative & Time	This Test	Base Level		Preservative & Time	This Test	Base Level	
	<0.007	( )	Arsenic		0.01	( )	Lead
	<0.5	( )	Barium		0.17	( )	Manganese
	0.02	( )	Boron		<0.001	( )	Mercury
	0.004	( )	Cadmium		<0.1	( )	Nickel
	<0.01	( )	Copper		0.002	( )	Selenium
		( )	Chromium (tri)		<0.05	( )	Silver
	<0.01	( )	Chromium (hex)		0.6	( )	Zinc
	0.2	( )	Fluoride		<0.008	( )	Cyanide
	11	( )	Iron (Total)		<0.01	( )	MBAS
	8.1	( )	Iron (Dissolved)		<0.001	( )	Phenol (ppm)
			BOD		3.3	( )	Oil & Grease
			Fecal Coliforms/ 100 ml		0.9	( )	Sulfides

SPECIAL INSTRUCTIONS

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 1 of 2)

Time Collected _____ Collector _____

Date Collected 10-31-74 Facility Name _____

Stream Name(s) Little Powder River

Source of Sample: (Exact Location) North Site #3

Physical Observations, Remarks: | Weather Cond. _____

Temp.(air) _____ °F
Ground Cond.

Flow	Field Dissolved Oxygen	Field pH	Field Temp.

CATIONS	meq/1	mg/1	(Base)	ANIONS	meq/1	mg/1	(Base)
Calcium (Ca)	0.81	16		Carbonate (CO_3)	0.00	0.0	
Magnesium (Mg)	2.09	25		Bicarbonate (HCO_3)	1.40	85	
Sodium (Na)	2.78	64		Sulfate (SO_4)	4.22	202	
Potassium (K)	0.19	7.4		Chloride (Cl)	0.23	9.5	
				Nitrate (NO_3)	0.01	0.8	
				*Phosphate (PO_4)as(P)	0.00	0.013	
				Fluoride (F)	0.01	0.2	
Total Cations	5.87			Total Anions	5.87		

Values reported are mg/1 unless otherwise stated.

*Not included in Total Anions

This Test	Base Level		
130	( )		Conductance (μmhos)
29.3	( )		COD
6.6	( )		pH
1400	( )		Turbidity (JTU)
145	( )		Hardness
42	( )		Alkalinity
	( )		Total Acidity
	( )		Free Acidity
	( )		
	( )		

This Test	Base Level		
7.8	( )		Ammonia (N)
36.5	( )		Organic Nitrogen (N)
0.8	( )		Nitrate + Nitrite (N)
0.025	( )		Total Phosphorus (P)
34,000	( )		Susp. Solids → 34,410 Total
31,300	( )		Vol.Susp.Solids
410	( )		ROE

FOR LAB USE ONLY

Lab Number: _____ Rec'd by: _____

Date sample rec'd: _____ Time: _____

Date analysis completed: _____

Date results forwarded: _____

Total tests requested: _____ Tests run: _____

Lab Section: _____ Supervisor: _____

Transported by: _____

Received by: _____

Transported by: _____

Received by: _____

Environmental Engineering - Water Pollution Control

Water Analysis Form (Page 2 of 2)

Time Collected: _____

Date Collected: 10-31-74

Stream Name(s): Little Powder River

Source of Sample: North Site #3

Special sampling and testing procedures are required for these water tests. Indicate on form if preservative has been added to sample and time tests were completed.

(Values reported are mg/l unless otherwise stated.)

Preservative & Time	This Test	Base Level		Preservative & Time	This Test	Base Level	
	<0.007	( )	Arsenic		<0.01	( )	Lead
	<0.5	( )	Barium		<0.05	( )	Manganese
	0.02	( )	Boron		<0.001	( )	Mercury
	<0.001	( )	Cadmium		<0.1	( )	Nickel
	<0.01	( )	Copper		0.002	( )	Selenium
		( )	Chromium (tri)		<0.05	( )	Silver
	<0.01	( )	Chromium (hex)		0.03	( )	Zinc
	0.2	( )	Fluoride		<0.008	( )	Cyanide
	19	( )	Iron (Total)		<0.01	( )	MBAS
	1.4	( )	Iron (Dissolved)		0.02	( )	Phenol (ppm)
			BOD		2.9	( )	Oil & Grease
			Fecal Coliforms/ 100 ml		0.0	( )	Sulfides

SPECIAL INSTRUCTIONS

CHAPTER V

DISCUSSION

In past years, little study has been focused upon the aquatic biota and abiota of the Little Powder River. Thus, it is not possible at this time to compare the findings of the 1974 study by WRRI with past conditions.

The fish species collected at the Little Powder study sites can be classified as cool and warmwater forms which can tolerate quite a wide range of environmental conditions. While water temperatures measured during 1974 reached a high of only 74°F (23.5°C), many of the species present can tolerate temperatures up into the 30° to 34°C range (Brett, 1956; Jones, 1964). Dissolved oxygen concentrations were quite high at each sampling time, with a low value of 6.9 mg/1 recorded on June 12. This level easily fell within the tolerance ranges of the species present, as most can exist down to approximately 2 mg/1 or less (Jones, 1964). Fry (1960), concluded that the general pH range for good fish production was from 6.7 to 8.6, while numerous investigators have found that the tolerance limits for most aquatic organisms range from 5.0 to 9.0 (Doudoroff and Katz, 1950; Hynes, 1966; Jones, 1964). The pH values for the Little Powder River were easily within these limits (range, 6.6 to 8.2).

The water quality parameter which appeared to have the greatest limiting effect upon the aquatic biota of the Little Powder River study sites was turbidity. As presented in the Results section, turbidity

measurements ranged up to 1500 Jackson Turbidity Units (JTU). However, the heavy rains which occurred during the sampling time (October) caused this exceptionally high value. It is felt that the June and August values, which ranged up to 181 JTU, are more indicative of normal conditions. The National Technical Advisory Board (1968) stated that little plant or benthic productivity can be expected when turbudity exceeds 200 JTU. By reducing light penetration and therefore photosynthesis, such high turbidity levels reduce the production of aquatic vegetation which serves as a food source, cover and egg deposition area for various aquatic organisms. Also, in a low-gradient stream such as the Little Powder, a large portion of the suspended material settles out, forming the thick mud substrate which was encountered at most locations. Generally, benthic production has been found to increase with increasing substrate size (Sprules, 1947; Kimble and Wesche, 1975). Deposited sediments reduce the size and number of interstices between these larger substrate particles, thereby reducing the living space available to many benthic invertebrates.

Both the abundance and the composition of the benthic fauna found at the Little Powder River study sites reflect the influence of the high turbidity in association with the low channel gradient. Averaging together all study sites and all sampling times, the mean relative abundance of benthic invertebrates was 44.7 per 0.1 m^2. Wesche (1974) sampled three sites on Little Rawhide Creek, a clear, weedy, ephemeral tributary of the Little Powder, on June 11, 1974, and reported an average of 363 benthic organisms per 0.1 m^2. Although no fish were present in Little Rawhide at the sampling locations, this comparison points out the effect which turbidity can have upon aquatic vegetation and subsequently,

invertebrate life. In terms of species composition, the three most abundant forms at the Little Powder River sites were oligocheates, Diptera larvae and Caenis sp., a mayfly. These invertebrates are commonly found living in the mud substrates of ponds, lakes and sluggish streams where they feed primarily upon organic detritus (Usinger, 1971; Hynes, 1970; Pennack, 1953). Noticeably absent among the bottom fauna were representatives of the orders Plecoptera (stoneflies) and Trichoptera (caddis flies) and other families of mayflies which require stream locations having higher water velocities and larger substrate sizes than were present at the study sites.

Other potential biological effects of high suspended sediment concentrations are (Cairns, 1967):

1) damage to the gills of fish by abrasion
2) blanketing the stream bottom and smothering fish eggs
3) reducing the effectiveness of "sight-feeding" fish
4) providing a surface for the growth of fungi and bacteria

Wallen (1951) found that the average turbidity level fatal to black bullheads was 222,000 mg/1, 69,000 mg/1 for sunfish, and 166,000 mg/1 for shiners. As suspended solids concentrations ranged up to only 38,330 mg/1 at the Little Powder River study sites, no direct fish mortality was observed or is expected. However, some gill damage may occur.

From the numbers of fish collected at the three study sites, it does not appear that egg survival is being greatly impaired by the turbidity. A possible explanation for this would be that the fish species present are primarily spring spawners. This coincides with the time of the year when streamflows are at their highest. Thus, water velocities

at this time may be sufficient to prevent heavy sediment buildup on the eggs. For species which provide parental care for the eggs (black bullheads, fathead minnows, longnose dace), the body and fin movements of the parents near the eggs would aid in preventing suffocation. Also, it should be noted that many species of the families Cyprinidae (minnows) and Catastomidae (suckers) are known to migrate upstream to spawn. Such migrations normally are initiated when water levels begin to rise with spring runoff (Hynes, 1970). Thus, it is possible that most spawning activity occurs upstream where physical and hydraulic conditions may be more favorable to spawning success. Following hatching, the young-of-the-year fish then disperse themselves throughout the stream.

The degree to which high turbidity levels affect the feeding effectiveness of the fish species collected at the study sites is not known. Either through morphological adaptation or particular variations and diversifications in feeding habits, it appears that the more abundant species can avoid severe food competition and obtain the necessary supplies, even though the relative abundance of bottom fauna was quite low. White suckers are primarily bottom feeders, using their inferior mouths to suck up bottom ooze and then strain out invertebrates. Sand shiners also feed on benthic organisms to some degree. Also, they feed upon diatoms in the bottom muds and terrestrial insects near the water surface. Black bullheads have four pairs of barbels located about their mouths which serve as sensory organs in locating food items along the substrate. While it may compete with other fishes for food, bullheads feed upon molluscs a great deal, a source not utilized by many other species. Also, small fishes may comprise a portion of the diet. Green sunfish have developed quite large eyes which may aid their sight in

turbid waters and also large, heavy mouths which enable them to feed on other fishes, large insects, both terrestrial and aquatic, and molluscs. The large eyes of the goldeye adapt it quite well to finding food under turbid conditions.

Although aquatic vegetation contributes little to the amount of organic debris available to the benthic fauna as a food source at the Little Powder River study sites, several other such sources exist. One would be the micro-organisms (fungi, bacteria) which may grow on the surface of the sediment particles and then become deposited on the stream bottom through the sedimentation process. Allochthonous material, such as the leaves, blossoms, fruits and pollens of terrestrial vegetation growing near the stream, may also help to provide the organic detritus necessary as food for the bottom fauna. A third source would be the tissues of dead organisms, both aquatic and terrestrial.

The cause of the high turbidity levels encountered at the Little Powder River study sites is related to the characteristics of the drainage basin. The drainage density for the basin was 0.85, quite a low value considering that normal values range from 1.5 to 2.5 and for well drained areas, 4 to 5. Strahler (1964) was of the opinion that low drainage density is preferable in regions of highly resistant or highly permeable subsoil materials, dense vegetative cover and low relief. High drainage density is preferable in areas of less resistant or impermeable subsurface materials, sparse vegetation and mountainous relief. In low drainage density situations, the length of overland flow is increased. In the Little Powder River basin, it appears that these longer lengths of overland flow allow more erosion to occur resulting in large sediment loads entering the stream.

The other water quality parameter found to approach levels which may adversely affect the aquatic biota of the Little Powder River was zinc. As shown on Table IV-16, page IV-38, zinc levels reached 0.26 mg/1 on August 20 at Site No. 1 and 0.6 mg/1 at Site 2 on October 31, although this latter value may be due to laboratory error. McKee and Wolf (1963), as reported in McGauhey, 1968, recommend a "threshold concentration" for zinc in freshwater of 0.1 mg/1. The "threshold concentration" is defined as a value that normally might not be deleterious to fish life. Waters which do not exceed this value should be suitable habitats for mixed fauna and flora. Cairns and Sparks, 1971, found that zinc concentrations of 0.25 mg/1 inhibited spawning in ripe bluegills (Lepomis macrochirus Rafinesque) and killed newly hatched fry. However, according to the National Technical Advisory Committee, 1968, the relationship between zinc toxicity, hardness of the water (calcium and magnesium concentration) and pH is confusing and not well understood. From the data collected on the biota of the Little Powder River, it does not appear that the zinc concentrations observed had a noticeable effect It is felt that the presence of zinc in these natural waters reflects the availability of zinc in the rock and soil of the drainage basin through which the water has passed (Hem, 1970).

A positive correlation between water quality changes, from site to site and for each of the sampling periods with aquatic biota may be possible in the future. For this study, the main intent and purpose has been to establish sampling stations and determine by water quality determinations what ionic concentrations are present in the Little Powder River at these stations.

As a second and important purpose for including the water quality determinations with this study, baseline water quality conditions will be established in the Little Powder River before any major industrial activity is initiated upstream of the sampling sites. Industrial activity planned for this drainage area includes strip mining and water storage reservoir development. In one case, strip mining operations will produce some water from below the natural ground level sources to be released to the surface streams. In the other case, storage reservoirs will accumulate surface and ground water and through control releases will regulate the total stream flow. A reservoir on the Little Powder River would also act as a settling basin to reduce turbidity and suspended matter in the trapped water.

Any sizable development in the upper basin will probably take several years. However, industrial activities on a limited scale will be in evidence during the spring of 1975. Early activities which will effect the water quality of the Little Powder River include change to the land form for plant site development and for roads. Dewatering of foundation sites and stock piling of strip mine overburden material will occur. Changes in water quality at the established sample station may be detectable from these early stage activities.

The water quality data has been presented in Table IV-16, page IV-38 for each of the constituents tested at the three sampling stations between May and October of 1974. These constituents have been listed in terms of maximum levels, minimum levels and expected range. Not all the values reported fell within the expected range due to the results of water quality sampling during a wet snow and rain storm encountered in October.

A comparison of expected ranges and maximum concentrations indicates

that chemicals will be leached from the natural mineral deposits to give high concentrations of sodium, sulfates and chlorides which will also be reflected in the specific conductance readings and total dissolved solids concentrations. Suspended solids and turbidity levels in the stream will be above expected range during high runoff periods.

Nutrient forms of nitrogen and phosphorus are within expected limits.

Concentrations of toxic metals varied slightly between sampling dates but did not show any excesses of concern. The possible effect of zinc concentrations above the 0.25 mg/l level has been discussed in relation to the aquatic biota. A continuing program of water quality sampling, testing and evaluation will be required to establish the complete range of toxic metal concentration.

CHAPTER VI

SUMMARY AND RECOMMENDATIONS

1. The aquatic biota and abiota of the Little Powder River on Thunder Basin National Grassland have been monitored during the summer and fall of 1974 to determine baseline conditions prior to development of mineral and water resources in the upper basin.

2. Through Thunder Basin, the Little Powder River is a narrow, meandering, low-gradient stream which drains approximately 550 square miles of land in the Powder River Basin of Northeastern Wyoming. Mean water depths for selected cross-channel transects at the three study sites ranged from 0.45 to 2.13 feet, while mean velocities ranged from 0.07 to 0.67 feet per second at a flow of 2.4 cfs. Top widths varied from 8 to 23 feet. The substrate at Site No. 1, located on the Ray Ranch 0.25 miles below the confluence of Cottonwood Creek, was entirely muck, reflecting its very low gradient (3.52 feet per mile). At Site No. 2, immediately below the Soda Well bridge, and Site No. 3, on the Norfolk Ranch, stream gradients were higher (7.39 and 9.50 feet per mile, respectively). Due to this and the resultant higher water velocities, scattered areas of fine gravel substrate were present at Sites 2 and 3.

3. The 11 fish species collected at the three study sites were cool and warmwater forms which are tolerant of quite wide ranges of environmental conditions. Standing crop estimates were made and fish populations were found to be quite dense, ranging from 2209 fish per surface acre at Site No. 2 to 2971 per acre at Site No. 1. Abundant

species were sand shiners, black bullheads, green sunfish, white suckers and fathead minnows. The bullhead and sunfish species are currently considered game fish species by the Wyoming Game and Fish Department. One goldeye was collected at Site No. 3. In Wyoming, this species is considered a rare and endangered species (status: undetermined).

4. Benthic fauna was not found to be abundant, averaging 44.7 organisms per 0.1 m^2 over all sampling sites and dates. Primary cause for such low numbers appears to be the high turbidity levels present which limit the growth of aquatic vegetation and thereby, the amount of cover and food available to invertebrate life. Other contributing factors would be heavy fish predation and the muck substrate. On a numbers basis, oligocheates were the most common form, followed by Diptera larvae and mayfly nymphs (g. Caenis). Considering biomass, freshwater clams ranked first in abundance, freshwater snails second and oligocheates third. Statistical analysis of benthic community structure revealed no significant differences occurred both between study sites and between sampling dates.

5. Water quality data has been presented for each of the constituents tested at the three sampling stations throughout the study period. Not all values reported fell within the expected range due to sampling during a wet snow and rain storm in October. The data collected indicate that leaching from the natural mineral deposits results in high concentrations of sodium, sulfates and chlorides, which is also reflected in the specific conductance readings and total dissolved solids concentrations. During high runoff periods, suspended solids and turbidity levels will be above expected ranges. Nutrient forms of nitrogen and phosphorus were within expected limites. Concentrations

of toxic metals varied slightly between sampling dates but did not show any excesses of concern, except for zinc concentrations, the possible effects of which have been discussed in relation to the aquatic biota.

6. It is the recommendation of the Principal Investigators that quarterly sampling of water quality and benthic fauna be conducted during 1975 to further identify baseline conditions of the Little Powder River through Thunder Basin National Grassland and to begin to assess the impacts of the upstream development scheduled to begin in 1975. It is also recommended that fish populations be sampled at least once during the year, preferably in the early summer.

CHAPTER VII

LITERATURE CITED

American Public Health Association. 1970. Standard Methods for the Examination of Water and Waste Water. 13th Ed. New York: American Public Health Association.

Battle, H. I. and Sprules, W. M. 1960. "A Description of the Semi-Buoyant Eggs and Early Developmental Stages of the Goldeye Hiodon alosoides (Rafinesque)." Journal of the Fishery Resources Board Canada, XVII, 245-65.

Baxter, George T. and Simon, James R. 1970. Wyoming Fishes. Bulletin No. 4. Cheyenne, Wyoming: Wyoming Game and Fish Department.

Black, E. C. 1953. "Upper Lethal Temperatures of Some British Columbia Freshwater Fishes." Journal of the Fishery Resources Board Canada, X, 196-210.

Brett, J. R. 1956. "Some Principles in the Thermal Requirement of Fishes." Quarterly Review of Biology, XXXI, 75-87.

Buckholz, M. M. 1957. "Life History of the River Carpsucker (Carpiodes c. carpio) in the Des Moines River, Iowa." Proceedings of the Iowa Academy of Sciences, LXIV, 589-600.

Cairns, J. 1967. Suspended Solids Standards for the Protection of Aquatic Organisms. Twenty-second Purdue Industrial Waste Conference, May 2-4, 1967. Purdue University.

Cairns, John, Jr. and Sparks, R. E. 1971. The Use of Bluegills to Detect Zinc. U.S. Environmental Protection Agency Water Pollution Control Research Series #18050 EDQ. Washington, D. C.: Government Printing Office.

Campbell, R. S. 1935. "A Study of the Common Sucker, Catostomus commersoni (Lacépède) of Waskesiu Lake." M.S. thesis, University of Saskatchewan, Saskatoon, Saskatchewan.

Carlander, K. D. 1969. Handbook of Freshwater Fishery Biology. Vol. I: Life History Data on Freshwater Fishes of the United States and Canada, Exclusive of the Perciformes. Ames, Iowa: Iowa State University, Press.

Chorley, Richard J., (ed.). 1969. Introduction to Fluvial Processes. London: Methuen and Co. Ltd.

Corbett, D. M. 1962. Stream-Gaging Procedures. U.S. Geological Survey Water Supply Paper No. 888. Washington, D.C.: Government Printing Office.

Cross, F. B. 1967. Handbook of Fishes of Kansas. University of Kansas Museum of Natural History Miscellaneous Publication No. 45. Lawrence, Kansas: University of Kansas.

Deacon, J. E. 1961. "Fish Populations, Following a Drought, in the Neosho and Marias des Coygnes Rivers of Kansas." University of Kansas Publications of the Museum of Natural History, XIII, 361-427.

De Lury, D. B. 1947. "On the Estimation of Biological Populations," Biometrics, III, 145-57.

De Lury, D. B. 1951. "On the Planning of Experiments for the Estimation of Fish Populations." Journal of the Fishery Resources Board Canada, VIII, 281-307.

Doudoroff, P. and Katz, M. 1950. "Critical Review of Literature on the Toxocity of Industrial Wastes and Their Components to Fish. I. Alkalies, Acids and Inorganic Gases." Sewage and Industrial Wastes, XXII, 1432-58.

Forney, J. L. 1955. "Life History of the Black Bullhead, Ameiurus melas (Rafinesque) of Clear Lake, Iowa." Iowa State College Journal of Science, XXXI, 145-62.

Fry, F. E. J. 1960. "Requirements for the Aquatic Habitat." Pulp and Paper Magazine of Canada, LXI, T.62-T.66.

Green, G. H.; Northcote, T. G.; Hartman, G. F.; and Lindsey, C. C. 1966. "Life Histories of Two Species of Catostomid Fishes in Sixteenmile Lake, British Columbia, With Particular Reference to Inlet Spawning." Journal of the Fishery Resources Board Canada, XXIII, 1761-88.

Harlan, J. R. and Speaker, E. B. 1951. Iowa Fish and Fishing. Des Moines: Iowa Conservation Commission.

Hem, John D. 1970. Study and Interpretation of the Chemical Characteristics of Natural Water (2nd Edition). U.S. Geological Survey Water Supply Paper 1473. Washington, D.C.: Government Printing Office.

Hunter, J. R. 1963. "The Reproductive Behavior of the Green Sunfish, Lepomis cyanellus." Zoologica, XLVIII, 13-24.

Hynes, H. B. N. 1966. The Biology of Polluted Waters. Liverpool: Liverpool University Press.

Hynes, H. B. N. 1970. The Ecology of Running Waters. Toronto: University of Toronto Press.

Jones, J. R. E. 1964. Fish and River Pollution. London: Butterworths.

Kennedy, W. A. and Sprules, W. M. 1967. Goldeye in Canada. Fishery Resources Board Canada Bulletin 161.

Kimble, L. A. and Wesche, T. A. 1975. Relationships Between Selected Physical Parameters and Benthic Community Structure in a Small Mountain Stream. Water Resources Series No. 55. Laramie, Wyoming: Water Resources Research Institute, University of Wyoming. In press.

Kuehn, Jerome H. 1949. "A Study of a Population of Longnose Dace (Rhinichthys c. cataractae)." Proceedings of the Minnesota Academy of Sciences, XVII, 81-87.

Markus, H. C. 1934. "Life History of the Blackhead Minnow (Pimephales promelas)." Copeia, III, 116-22.

McGauhey, P. H. 1968. Engineering Management of Water Quality. New York: McGraw-Hill Book Co.

McKee, J. E. and Wolf, H. W. 1963. "Water Quality Criteria." Report to Paul R. Bonderson, California State Water Quality Control Board. (Mimeographed.)

McPhail, J. D. and Lindsey, C. C. 1970. Freshwater Fishes of Northwestern Canada and Alaska. Fishery Resources Board Canada Bulletin 173.

Meyer, W. H. 1962. "Life History of Three Species of Redhorse (Moxostoma) in the Des Moines River, Iowa." Transactions of the American Fishery Society, XV, 412-19.

Minckley, W. L. 1973. Fishes of Arizona. Phoenix, Arizona: Sims Printing Co., Inc.

Mueller, J. W. 1974. Personal communication.

National Technical Advisory Committee. 1968. Water Quality Criteria. Report to the Secretary of the Interior. Washington, D.C.: Federal Water Pollution Control Administration.

Odum, Eugene P. 1971. Fundamentals of Ecology. 3rd ed. Philadelphia: W. B. Saunders Company.

Olund, L. J. and Cross, F. B. 1961. "Geographic Variation in the North American Cyprinid Fish, Hybopsis gracilis." University of Kansas Publication of the Museum of Natural History, XIII, 323-48.

Pennack, R. W. 1953. Freshwater Invertebrates of the United States. New York: The Ronald Press Co.

Reed, E. B. 1962. Limnology and Fisheries of the Saskatchewan River in Saskatchewan. Fisheries Branch, Department of Natural Resources, Saskatchewan Fisheries Report No. 6.

Reighard, J. 1920. "The Breeding Behavior of the Suckers and Minnows." Biological Bulletin, XXXVIII, 1-32.

Scott, W. B. and Crossman, E. J. 1973. Freshwater Fishes of Canada. Canadian Fisheries Resources Board Bulletin No. 184.

Simpson, J. C. 1941. Food Analysis of Some Important Species of Wyoming Forage Fishes. M.S. thesis, University of Wyoming, Laramie, Wyoming.

Sprules, W. M. 1947. An Ecological Investigation of Stream Insects in Algonquin Park, Ontario. University of Toronto Studies, Biological Series No. 56. Ontario Fishery Resources Laboratory Publication No. 69.

Starrett, W. C. 1951. "Some Factors Affecting the Abundance of Minnows in the Des Moines River, Iowa." Ecology, XXXII, 13-27.

Strahler, A. N. 1964. "Quantitative Geomorphology of Drainage Basins and Channel Networks." Handbook of Applied Hydrology. Edited by V. T. Chow. New York: McGraw-Hill Book Co.

U.S. Department of the Interior. 1974. Final Environmental Impact Statement: Eastern Powder River Coal Basin of Wyoming. Washington, D.C.: Government Printing Office.

U.S. Department of the Interior. Geological Survey. 1973. Water Resources Data for Wyoming. Part 1. Surface Water Records. Washington, D.C.: Government Printing Office.

Usinger, R. L., (ed.). 1971. Aquatic Insects of California. Berkeley: University of California Press.

Wallace, C. R. 1967. "Observations on the Reproductive Behavior of the Black Bullhead (Ictalurus melas)." Copeia, IV, 852-53.

Wallen, F. E. 1951. "The Direct Effect of Turbidity on Fish." Bulletin of the Oklahoma Agricultural Mechanics College, XLVIII, 27.

Welch, P. S. 1948. Limnological Methods. New York: McGraw-Hill Book Co.

Wesche, Thomas A. 1974. "Environmental Baseline Studies for AMAX Belle Ayr Mines." Chapter 5. Aquatic Biology. Laramie, Wyoming: Water Resources Research Institute, University of Wyoming. (Typewritten.)

Wilhm, Jerry L. 1967. "Comparison of Some Diversity Indices Applied to Populations of Benthic Macroinvertebrates in a Stream Receiving Organic Wastes." Journal of the Water Pollution Control Federation, XXXIX, 1673-83.

Wilhm, Jerry T. and Dorris, T. C. 1968. "Biological Parameters for Water Quality Criteria." BioScience, XVIII, 477-81.

Wynne-Edwards, V. C. 1932. "The Breeding Habits of the Black-Headed Minnow (Pimephales promelas Raf.)." Transactions of the American Fishery Society, LXII, 382-83.

Wyoming. Game and Fish Department. Wyoming's Rare and Endangered Wildlife. Cheyenne, Wyoming: Wyoming Game and Fish Department.